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TULANE STUDIES IN ZOOLOGY AND BOTANY

VOLUME 15
1968–1969

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SPEOCIROLANA THERMYDRONIS (CRUSTACEA: ISOPODA) FROM NORTHEAST MÉXICO, RE-DISCOVERY, HABITAT, AND SUPPLEMENTAL DESCRIPTION

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New Orleans, Louisiana p. 10

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ROYAL D. SUTTKUS
and
GLENN H. CLEMMER
Department of Biology, Tulane University
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Editors' Note

Effective with Volume 15, Number 1, the name of the biological journal published by Tulane University will be *Tulane Studies in Zoology and Botany* instead of *Tulane Studies in Zoology*. The Departments of Zoology and Botany were united into a single Department of Biology some time ago. The name change for the journal reflects a desire of the biology faculty to include botanical papers. Policies with regard to editorial review and exchanges remain the same.

SPEOCIROLANA THERMYDRONIS (CRUSTACEA: ISOPODA) FROM NORTHEAST MÉXICO, RE-DISCOVERY, HABITAT, AND SUPPLEMENTAL DESCRIPTION

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Department of Zoology, Arizona State University, Tempe, Arizona 85281

ABSTRACT

Speocirolana thermydronis, previously known from a single specimen, was rediscovered in interstices of travertines that rim large spring-fed pools near Cuatro Ciénegas Coahuila, México. The 29 new specimens differ little from the original description, but some variations are described.

Speocirolana thermydronis Cole and Minckley (1966) was described from a single, large female collected 12 April 1964 near Posos de la Becerra, 13.7 km southwest of Cuatro Ciénegas, central Coahuila, México. In August 1967, 29 additional specimens were caught, 22 from an unnamed poso (sinkhole) *ca.* 12 km southwest of Cuatro Ciénegas, and 7 specimens from the west laguna of El Mojarral, 11 km southwest of that town. Considerable time spent at a number of other places, including the area of original discovery, failed to obtain the isopod.

Habitats.—The unnamed poso is a spring tributary to the west laguna of El Mojarral. Its dimensions are about 10 by 12 m, by about 2 m deep. There was about 0.85 m of water in the pit, over a dark, flocculent bottom of silt, shells of the snails *Paludiscala caramba* Taylor and *Durangonella* sp., and travertine blocks and fragments. The banks are of gypsum, matted roots of desert plants, and travertine. The inflowing water was 34° C. This is the type-locality of *P. caramba*, the most distinctive of the freshwater snails of the Cuatro Ciénegas basin (Taylor, 1966: 207-8).

The second locality for *S. thermydronis*, the western limnocrene in the marshy area called El Mojarral, has been described by Taylor (1966:163, pls. 9-10). It is a large, clear pool, about 25 by 100 m and up to 5 m deep. Large springs enter at the northwest end and water leaves by a subsurface channel and by small surface outflows at the southeast. Water temperatures at the inflow are about 33° C, but some variations occur in places remote from the source. Much of the bottom is soft, gray, flocculent silt, stabilized locally by beds of waterlily, *Nymphaea* sp. Banks are undercut and mostly of gypsum and travertines.

All our new specimens of *S. thermydronis* were collected by manually breaking large, loosely-cemented, porous travertine blocks that were abundant around the margins of the pools. In some instances, individual isopods moved from interstices of a block as water drained from it, and could be picked from the surface. Minckley (1961:454) described similar habitats for a troglobitic asellid, *Asellus stygius* (Packard), in porous marls of Doe Run, Meade County, Kentucky. *S. thermydronis* was accompanied in its habitat by an undescribed species of aquatic isopod, by an aquatic mite, and by an oligochaete. The last three animals also lived in the softer sediments; however, *S. thermydronis* was consistently absent from such places. It seems unlikely that *S. thermydronis* moves extensively within the sediments that characterize most lagunas of the Cuatro Ciénegas area. Living specimens retained in the field soon became entangled with loose sediment particles on the bottoms of their containers, and were distinctly incapacitated. *A. stygius* is similarly affected under certain conditions (Minckley, 1961: 454). Life on the surface of the undisturbed sediments also is most likely limited to places where fishes are absent; as many as 12 species of fish, many of which are highly predaceous, occur in larger springs of the area.

EDITORIAL COMMITTEE FOR THIS PAPER:

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DR. ALFRED E. SMALLEY, Associate Professor of Biology, Tulane University, New Orleans, Louisiana

Neil F. Hadley (personal communication), now of Arizona State University, was with Mary L. Allesio when she collected the holotype in 1964, and has provided additional data on the type-locality. The holotype was one of three, similarly-sized individuals observed in a small pit, about 0.5 m in diameter and one m deep, *ca.* 0.6 km south of the head-spring of Posos de la Becerra. The animals were in the shade and were moving about on the surface of gray, flocculent sediment beneath about 0.25 m of water. The pit was near extensive marshes that existed downflow from La Becerra prior to diversion of water by canalization in late 1964 (Cole and Minckley, 1966). The entire marsh-river-poso complex south and west of La Becerra now is dry, and during core-drilling operations in 1967 the water table was encountered about 3 m below the land surface—there is little doubt that the point of original capture also is destroyed.

Our failure to find *S. thermydronis* in the remaining habitats of Posos de la Becerra may be attributed, in part, to destruction by desiccation of most marginal deposits of suitable travertine. The sudden drying of the laguna decimated fish and endemic snail populations (Minckley, in Taylor, 1966: 162-3). In 1967, some of the snails were becoming re-established, as may *S. thermydronis*, as the habitat stabilizes. On the other hand, absence of the species from apparently suitable habitat in a number of other springs diminishes somewhat the importance of its apparent absence in La Becerra. This may result from the well-known vagaries of collecting such secretive organisms. Much of the basin floor has water within a meter of its surface; numerous large, subterranean channels are known, and interstitial habitat for *S. thermydronis*, as well as for other animals, must be exceedingly abundant. We have little doubt that additional specimens and habitats will be found.

Supplemental description.—Those features of *S. thermydronis* adequately described in our original paper are not elaborated here. We find that part of the description was in error, however, and reproduce that section (Cole and Minckley, 1966:18), with corrections in boldface type, as a footnote.[1] In addition, the second and third pereonites of *S. thermydronis* bear epimera, as do other species of the genus—their absence in the holotype was due to an artifact of preparation, as was suspected.

Body shape and proportions in *S. thermydronis* are quite constant. The telson, broad and acutely tipped in both sexes, seems a good character separating the Coahuilan form from *S. pelaezi* (telson broadly rounded) and *S. bolivari* (telson truncate).

It appears that length and number of segments in the antennal flagella in the genus *Speocirolana* may vary considerably with size, with larger individuals tending to add length and segments. All specimens of *S. thermydronis* are small (the holotype at 15 mm is largest), whereas *S. pelaezi* ranges from 19 to 26 mm and *S. bolivari* from 15 to 35 mm (Bolivar y Peltain, 1950; Rioja, 1953). The second antenna of the 15-mm holotype of *S. thermydronis* reaches posteriad to the seventh pereonite (as in *S. pelaezi*). In the smaller, new specimens of *S. thermydronis*, the maximal extension is to the fifth pereonite. And, in the large *S. bolivari*, its extension is far past the seventh. Articles in the first antennal flagellum of *S. thermydronis* range from 6 to 14 (including the holotype, at the maximum). The second antenna is similarly variable, ranging from 25 to 35 (with the large holotype again bearing the maximum). *S. bolivari* has 22 to 28 segments in the first antennae, and 48 to 82 in the second, and *S. pelaezi* has 20 and 30 segments, respectively. The relative elongation of terminal segments in the second antennal flagellum is variable—the holotype has long terminal segments (as in *S. pelaezi*), yet some smaller specimens have shortened segments indistinguishable from those of *S. bolivari*.

The inner plate of the first maxilla of *S. thermydronis* is invariable in bearing three sparsely-plumose spines and two delicate setae. The outer plate, however, often has as many as 12 strong, distal spines (10 in the holotype).

The maxilliped of *S. thermydronis* seems highly diagnostic. Penultimate and ante-

[1] In *S. thermydronis* the mandibles (Fig. 6) are asymmetrical, with the **left** incisive process overlapping the **right** ventrally. The **pars molaris** of the mandible is sub-triangular, bearing on its margin about 34 short, cone-shaped teeth.

penultimate segments of the palp have only fine, hairlike setae on their outer surfaces, except for a strong spine at each of their distal corners. The ultimate segment is sometimes naked on its outer surface, as in the holotype, but in some specimens there are fine hairlike setae on the proximal half. The outer surfaces of the last three palp segments in *S. bolivari* are strongly setaceous, and such a condition also is found on the penultimate and antepenultimate segments in *S. pelaezi.* These species, however, lack the strong, isolated spines at the distal, outer corners of the last two segments. Such a spine is present only on the first segment of their palps (Bolivar y Peltain, 1950:Fig. 5; Rioja, 1953:Fig. 18).

All pereopods of *S. thermydronis* are essentially as described, except for variable armament on the subcheliform, first three pairs. The holotype has the palmar margins of the propodus armed with 2, 3, and 4 stout spines, respectively; many of the new specimens have 2, 4, and 4 such spines.

The exopod of the fifth pleopod of the new material (rather than the fourth, as erroneously given for the holotype) is only sparsely invested with plumose setae. We also find that both sexes of *S. thermydronis* lack distal setae on the endopodites of all pleopods. Presence of such setae on the first two pleopods, and their absence on the succeeding three, as in *S. bolivari* and *S. pelaezi,* is therefore not a character of generic rank as was tentatively suggested by Bowman (1964:233-4). Distribution of setae on the pleopods does, however, provide good specific characterization—*S. bolivari* has setae on endopods of at least the first and second pleopods in males (Rioja, 1953: Figs. 28, 30); *S. pelaezi* has setae on the endopod of the first pleopod in females and at least the second in males (Bolivar y Peltain, 1950:Figs. 9, 11); and, as given before, all pleopodal endopods of both sexes of *S. thermydronis* lack setae.

Except for the modified second pleopods of the male, no sexual dimorphism is obvious in the genus *Speocirolana.* The copulatory organ of *S. thermydronis* rises from the base of the pleopodal endopod. The organ is variable in length, ranging from slightly shorter to slightly longer than the endopod.

Living specimens of *S. thermydronis* have ivory-white exoskeletons, with dark-brown or black masticatory surfaces on the mandibles and terminal claws of the pereopods. In addition, the spines on the pereopods are straw-yellow. There is a variable amount of red-to-brownish pigment associated with internal organs, and this is visible through the dorsum of living animals, but fades rapidly to light-brown or yellow in alcoholic material.

Specimens of *S. thermydronis* from the 1967 collections are housed at the U. S. National Museum, Washington, D. C., the Instituto Nacional de Investigaciones Biológico Pesqueros, México, D. F., and the National Museum of Canada, Ottawa, Ontario. A permit for collection of aquatic animals in México was supplied by the Dirección General de Pesca e Industrias Conexas, México, D. F. Numerous personnel of Arizona State University deserve thanks for help in the field and in the laboratory. Studies were supported, in part, by Grants GB-2461 and GB-6477X from the National Science Foundation.

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October 16, 1968

A NEW CRAWFISH OF THE GENUS *PROCAMBARUS* FROM MISSISSIPPI (DECAPODA, ASTACIDAE)

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ABSTRACT

A new crawfish species of the Spiculifer Group, Blandingii Section, of the genus *Procambarus* is described from tributaries of the Tombigbee River in eastern Mississippi. *P.* **lagniappe**, new species, is related to *P. penni* and *P. spiculifer*.

The first specimens of the species described here were collected on June 16, 1955 by the late George H. Penn and me from two creeks in Kemper Co., Mississippi (Tombigbee River drainage). Dr. Penn first identified these specimens as *Procambarus penni* Hobbs (1951:273). Later he changed the labels to read "atypical *P. versutus*" (Hagen, 1870:51). In August, 1965, I collected in this area again, finding additional similar specimens recognizing them as an undescribed species.

This species belongs to the Spiculifer Group of the Blandingii Section of the genus *Procambarus* and is the fourth species, to date, of this group to be recorded from Mississippi. Other species are *P. penni* from the Pearl and Pascagoula River drainages, *P. ablusus* Penn (1963:121) from the Hatchie River drainage, and *P. vioscai* Penn (1946:27) from the Pearl, Amite, Tangipahoa, Homochitto, Big Black, Yazoo, Wolf, and Tombigbee River drainages.

I wish to express my gratitude to Dr. Horton H. Hobbs, Jr., Senior Zoologist, Smithsonian Institution, for examination of specimens and confirmation of identification. Thanks are also due Dr. Alfred E. Smalley, Tulane University for the loan of specimens of this species from the Tulane University collections.

Procambarus **lagniappe**,[1] new species

Diagnosis.—Body pigmented; eyes normal. Rostrum with prominent marginal spines; acumen attenuate, constituting 43.3-44.5 per cent of total length of rostrum; postorbital ridges terminating in spines; suborbital angle much reduced; lateral surface of carapace with two cervical spines. Areola 5.0-6.2 times longer than wide, constituting 25.3-27.7 per cent of entire length of carapace. Simple hooks present on ischiopodites of third and fourth pereiopods; basipodites of fourth pereiopods bear an opposable tubercle on cephalic surface. First pleopod of first form male (Figs. 1, 6, 12) without shoulder on cephalic margin, terminating distally in three distinct elements; mesial process subspiculiform and directed caudodistally with only tip corneous; cephalic process lacking; caudal process represented by low hemi-disc arising from much reduced caudal knob; central projection corneous, subacute, extending caudodistad at about 60 degree angle to axis of pleopod shaft; fusion lines of its component elements clearly marked. Annulus ventralis as figured (Fig. 9).

Holotypic male, Form I.—Carapace (Figs. 3, 7) subovate, slightly compressed laterally; abdomen slightly longer than carapace (39.0 and 38.2 mm, respectively). Maximum height of carapace slightly more than maximum width (16.8, 15.4 mm). Areola relatively broad and short (constituting 25.6 per cent of entire length of carapace), about

[1] Creole French: in Louisiana, a little something extra given to customers by tradesmen.

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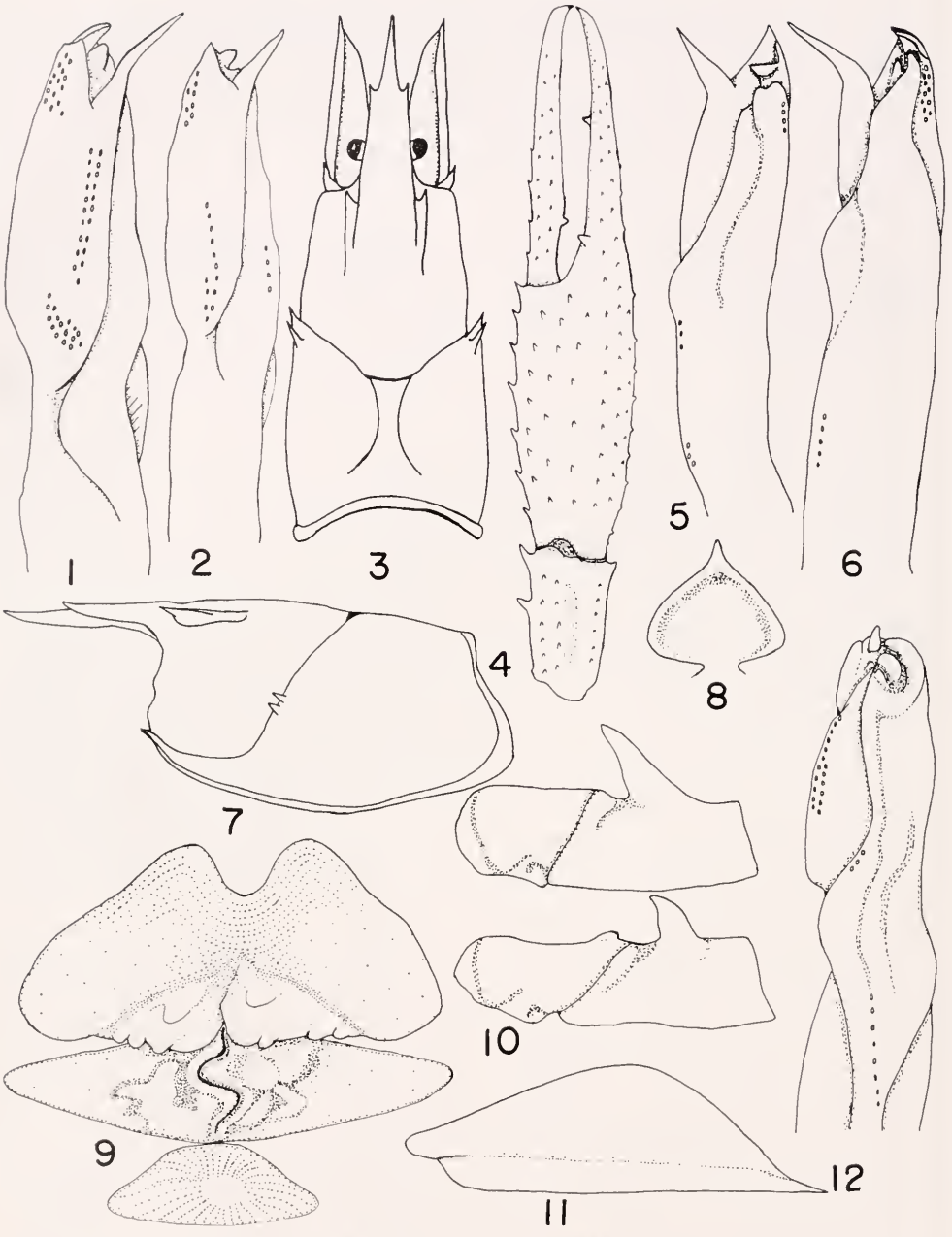

Figures 1-12. *Procambarus lagniappe*, new species; 1. Mesial view of first pleopod of holotype; 2. Mesial view of first pleopod of morphotype; 3. Dorsal view of carapace of holotype; 4. Upper view of carpus and chela of holotype; 5. Lateral view of first pleopod of morphotype; 6. Lateral view of first pleopod of holotype; 7. Lateral view of carapace of holotype; 8. Epistome of holotype; 9. Annulus ventralis of allotype; 10. Basipodites and ischiopodites of third (upper) and fourth (lower) pereiopods of holotype; 11. Antennal scale of holotype; 12. Caudal view of first pleopod of holotype (pubescence removed from all structures illustrated).

five times as long as wide, with five fine punctations in narrowest part. Cephalic portion of carapace nearly three times as long as areola. Rostrum long, acumen extending cephalad beyond peduncle of antennule, excavate; with acute marginal spines. Rostrum widest at base, margins elevated and converging anteriorly; no median carina. Acumen long and thin. Postorbital ridges well developed, each terminating cephalad in acute spine; punctations along mesial surfaces of ridges, tubercles along lateral surfaces. Brachiostegal spine well developed. Suborbital angle much reduced. Cervical groove interrupted on each side by two conspicuous acute spines. Upper two-thirds of carapace punctate, lower one-third strongly granulate.

Epistome (Fig. 8) with raised lateral margins converging toward small cephalomedian spine. Cephalic section of telson with three spines in each corner.

Antennules of usual form, with prominent acute spine on ventral side of basal segment. Antennae not quite reaching tip of abdomen. Antennal scale (Fig. 11) long, tip extending beyond tip of acumen, widest slightly proximal of midlength, outer distal margin with strong spine.

Chela (Fig. 4) ovoid in cross-section, long, slender; single row of seven tubercles along inner margin of palm; smaller tubercles in six irregular longitudinal rows on upper surface of palm. Both fingers terminating in short, corneous tips bent toward each other. Movable finger with one prominent tooth on opposable margin near base. Immovable finger with two prominent, widely spaced teeth on opposable margin. Fingers long; dactyl about 53 per cent of total length of outer margin of chela. Carpus (Fig. 4) ovoid in cross-section; with two prominent, acute tubercles in distal half of inner margin; few squamous tubercles arranged in two rows between inner margin and longitudinal groove. Basipodite of first pereiopod without spines. Ischiopodites of first pereiopods each with four spines on inner margin.

Hooks on ischiopodites (Fig. 10) of third and fourth pereiopods simple, subequal in length; basipodites of fourth pereiopods each bearing small tubercle on distal cephalic surface opposite hook. Apophyses on coxopodites of fourth and fifth pereiopods with caudomesial projections; that on fourth knoblike, that on fifth compressed and acute.

First pleopod (Figs. 1, 6, 12) extending to middle of coxopodite of third pereiopod when abdomen flexed. Pleopod essentially straight; terminating in three distinct elements; mesial process subspiculiform and directed caudodistally at about 55 degree angle to axis of main shaft, tip corneous; cephalic process lacking; caudal process low, flattened corneous hemi-disc; caudal knob low, reduced; central projection corneous, subacute, extending caudodistad at 60 degree angle to axis of main shaft, fusion lines of component parts clearly defined. Pleopods asymmetrical with base of left displaced in plane posterior to right.

Allotypic female.—Differs from holotype in following respects: rostrum more slender, acumen proportionately longer; areola proportionately narrower; rostrum widest slightly cephalad of base; tip of antennal scale reaching tip of acumen; chela proportionately wider, thicker; antennae extend caudad to middle of fifth abdominal segment. Annulus ventralis (Fig. 9) movable; spindle-shaped, widest in transverse axis; cephalic margin partially obscured by several tuberculate prominences extending caudad from sternum immediately cephalic to it; sinus originating near midcephalic margin and forming sinuous line to near midcaudal margin of annulus. Area adjacent to sinus raised, smooth.

Morphotypic male, Form II.—Differs from holotype in following respects; carapace less compressed laterally; height and width of carapace subequal; areola proportionately wider (4.5 times as long as wide); antennae extending caudad to caudal margin of telson; chela and hooks on ischiopodites reduced; caudomesial processes on coxopodites of fourth and fifth pereiopods less well developed; ischiopodites of each first pereiopod with three spines. First pleopods (Figs. 2, 5) asymmetrical, right pleopod reaching almost to anterior edge of coxopodite of third pereiopod when abdomen flexed, left displaced posteriorly reaching to middle of coxa of third pereiopod. All terminal elements present but less acute and noncorneous; caudal knob more prominent.

Type Locality.—Pawticfaw Creek (tributary to Sucarnoochee Creek, in turn a tributary of Tombigbee River) 6.0 miles south of DeKalb, Kemper County, Mississippi, at

Measurements (in mm).—

	Holotype	Allotype	Morphotype
Carapace:			
length	38.2	48.0	34.8
width (max.)	15.4	19.6	14.5
height (max.)	16.8	20.6	14.5
Abdomen length	39.0	49.7	36.5
Areola:			
length	9.8	12.5	9.0
width (min.)	1.8	2.0	1.8
Rostrum:			
length	14.8	19.0	13.3
width	5.2	6.8	4.9
length of acumen	6.6	9.1	6.1
Antennal scale:			
length	13.3	15.5	11.5
width	4.1	5.0	3.8
First pleopod length	9.5	--	7.9
Right chela:			
length, outer margin	30.3	31.5	21.0
length, dactyl	15.8	16.8	11.8
width, palm	7.4	8.9	5.1
thickness of palm (max.)	5.6	6.2	3.5

Mississippi Highway 39. Here the stream varies in width from 10 to 30 feet, with a bottom of white sand and plant debris. The water is clear, with good current, suggestive of a spring-fed stream. Other crawfishes present include an unidentified species of *Orconectes* (no first form males collected), which was predominant and was only found in piles of plant debris. All specimens of *P. lagniappe* were taken from scattered growths of *Vallisneria* in the swifter parts of the stream.

Disposition of types.—The holotypic male, Form I, the allotypic female and the morphotypic male, Form II, all from the type locality, are deposited in the United States National Museum (nos. 119088, 119089, 119090, respectively). The following paratypes are retained in my personal collection at McNeese State College: JBB 108 (type locality)—one ♂ I, five ♂♂ II, two ♀♀; JBB 206 (type locality)—one ♂ II. Paratypes in the Tulane University Collections are: TU 3174, Blackwater Creek, 7.8 miles south of DeKalb—one ♂ I, three ♀♀, GHP and JBB coll.; TU 3613 (type locality)—one ♂ I, one ♂ II, one ♀, JBB coll.

Color notes.—Background color of most of the dorsal part of the carapace is medium brown. The sides of the cephalic and thoracic region are marked by an incomplete (in the mid-dorsal area of the areola) U-shaped yoke of olive brown. The yoke increases in width caudally and is widest at caudal edge of carapace where the base of the U almost meets in the median line. A large cream colored area is below the "yoke" on the cephalic portion, which area darkens to light olive-tan on the thoracic portion of the carapace. The mid-dorsal portion of the abdomen is marked by a lightly-defined stripe of medium brown. On either side of this stripe, the background color is cream. The caudal portion of each abdominal segment is deep olive brown. A deep, olive brown, lateral "V" connects the caudal portions of adjacent segments. A pair of small, rectangular, deep olive brown blotches mark the cephalolateral portion of each segment. Between the transverse caudal stripes and above the "V" on either side is a rust-colored blotch on the second through fifth abdominal segments. The cephalic section of the telson is marked by an inverted cream colored crescent surrounded by olive brown, the caudal section is uniformly medium brown. The bases of the uropods are cream, with mesial rectangular stripes of dark brown surrounded by a large area of rust brown. The palms of the chelae are medium brown with dark olive brown tubercles. The dactyl and immovable finger are dark olive brown, except for cream colored tips.

Variations.—There are few variations of import in observed specimens. The annuli ventrales of smaller adult females are significantly different. Smaller females do not possess tuberculate prominences on the sternum just cephalic to the annulus ventralis. Also the median sinus on the annulus ventralis of smaller females is less deeply sculptured and shows less lateral twisting.

Relationships.—On the basis of the structures of the first pleopod of Form I males, *P. lagniappe* is most closely related to *P. spiculifer* (LeConte, 1856:401), resembling it in lacking a distinct cephalic process, but differing from it in having a much reduced caudal knob. This resemblance may be more superficial than actual. Geographically, its closest Spiculifer Group relative is *P. penni* Hobbs (1951:273). Second form males show a closer resemblance to *P. penni* than

to *P. spiculifer;* also the annuli ventrales of females of *P. penni* and *P. lagniappe* are markedly similar.

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OBSERVATIONS ON THE BEHAVIOR AND ECOLOGY OF THE NUTRIA IN LOUISIANA

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Abstract

A population of feral nutria (*Myocastor coypus*) on Tulane University's Riverside Campus near Belle Chase, Plaquemines Parish, Louisiana, was observed at 2-3 day intervals from January 29, 1967, through July 11, 1967. Twenty-eight nutria were trapped, marked with permanent numbered tags and with distinctive field markers, and released. There were 21 recaptures. Activity peaked at noon, late afternoon, and late evening. No observations were made of predawn activity. The major type of activity changed from sunning to constant grooming and feeding with increasing ambient temperatures. Solitary nutria were rarely observed. Daily cruising ranges of nutria were usually less than 200 yds. Preference was shown for areas of shade and areas covered by duckweed. Nutria lived colonially in large dens built into the banks of ponds. Each colony lived in a separate den; a typical colony consisted of 15-20 nutria. No nests or platforms were built; instead, floating objects or exposed roots of willow trees were utilized for sunning and feeding. The main diet was duckweed (*Lemna minor*, *Wolfia* sp., and *Wolfiella floridana*) and white clover (*Trifolium* sp.).

Within each social group, there was one alpha female and one alpha male; all other animals were equally subordinate. The alpha female dominated the alpha male. Aggression consisted of warning sounds ("mooing") and chasing subordinate animals. Fighting was ritualistic in the water. There was little care of young by the mother and no attempt was made to protect them from predators. Garfish, snakes, and red-shouldered hawks took young nutria. Man was the major predator on adult nutria. When alarmed, nutria assumed a "watching" position in the water, or dived underwater, slapping the water with the hind feet to produce an alarm sound.

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The South American beaver or nutria, (*Myocastor coypus*), is a large hystricomorph rodent which was first successfully introduced into Louisiana from Argentina by E. A. McIlhenny in March, 1937, as a fur animal to be raised in captivity. The subspecies found in Louisiana and Texas, according to Lowery (1943), is *Myocastor coypus bonariensis,* a form native to northern Argentina, Uruguay, Paraguay, and southern Brazil. Many nutria which escaped or were released from fur ranches have established feral colonies throughout Louisiana (Harris, 1956). These colonies have done great damage in agricultural areas, especially to rice and sugar cane crops (Evans, pers. comm.). In an effort to develop some method of control, much interest has arisen in the behavior and ecology of nutria.

Tulane University's Riverside Campus near Belle Chase, Plaquemines Parish, Louisiana, supports a moderately large, relatively isolated population of nutria. The purpose of this paper is to report on a study of the habits and habitat of this population of feral nutria.

Description of Study Area

Three interconnected ponds (comprising an area of 130,000 sq ft) were chosen as the study site. Two biotic communities were found around these ponds. Disturbed areas, which had been cleared of trees and shrubs, were in closely-cropped grass and white clover, *Trifolium* sp. Undisturbed areas, which surrounded the ponds on three sides, were typical lowland wooded habitat. The dominant vegetation was *Acer rubrum, Ulmus americana, Populus deltoides, Acer negundo, Salix nigra, Myrica cerifera, Quer-*

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cus virginiana, Corundus drummondi, Celtis laevigata, and *Sambucus canadensis.* Several species of the mustard family grew along the water's edge wherever there was sufficient sunlight.

During this study, the ponds were always covered to some extent by a mixture of *Lemna minor, Wolfia* sp., and *Wolfiella floridana* (all referred to as "duckweed" in the remainder of the paper). During February and early March, this cover was relatively sparse, but by April, a thick blanket of aquatics covered the ponds. All ponds contained numerous underwater fallen logs on which the nutria sat while eating. Many of these logs were later exposed when water levels in the ponds dropped.

Methods and Materials

Nutria were observed in the study area at regular (2-3 day) intervals from January 29, 1967, through July 11, 1967. Attempts were made to observe nutria activity at all hours, but due to lack of adequate night-viewing equipment, most observations were made during daylight hours. Observations usually lasted 3-4 hours (for a minimum total of 200 hrs), and whenever possible, air and water temperatures, as well as current water conditions, were recorded for each group of observations. Most observations (75%) were made from a boat in the center of the first pond.

Nutria were trapped, marked, and released during three different periods. On March 1, 1967, ten traps were placed around the edges of two ponds in areas showing definite signs of nutria activity. Traps used were double-door treadle traps, 10″ × 10″ × 32″, baited with carrot cubes. Traps were set with both doors open. These traps were removed on March 10, 1967. On April 19, 1967, one 4′ × 4′ raft was placed in the center of the first pond. During the second period of trapping, four traps of the same size as above, baited with carrots, were placed on this raft and trapping continued for six days (April 24-30). On the raft, only one door of each trap was opened and the traps were arranged so that each one had a "lead-in" of carrot bits. On May 19, 1967, a second raft, 4.5′ x 6.5′, was placed on the third pond. During this period of trapping, six traps were placed on this raft and four traps were placed on the raft in the first pond. Trapping started on June 26, 1967; all traps were removed on July 2, 1967.

Each captured nutria was removed from the trap by means of a handling bar, measured, weighed, and then marked in three ways: by a National #3 metal numbered tag through the cartilage of the left ear, by a correspondingly numbered #3 tag in the webbing of the left hind foot, and by a distinctively colored plastic flag pinned by a stainless steel safety pin through the skin of the nape of the neck. The numbered tags were for long-term identification; the nape marker was for field identification and was generally short-term due to sloughing. Each animal was released at the site of capture.

If a nutria was recaptured, the location of the trap and the animal's number were recorded. The nutria was then measured and weighed, and if necessary, the nape marker was replaced.

Samples of the vegetation around the study ponds were collected regularly from February through July, 1967. Specimens were pressed, dried, identified, and placed in the Environmental Biology Herbarium of Tulane University to be mounted at a later date.

Results and Discussion

In the first ten days of trapping, 19 nutria were marked and 3 were recaptured. Marked animals included 8 adult females, 5 juvenile females, and 5 juvenile males. One adult male was taken. Two juvenile females and 1 juvenile male were recaptured. In the second period of trapping, 5 nutria (3 juvenile males, 1 juvenile female, and 1 adult female) were recaptured a total of 11 times, but only 1 new animal, a juvenile male, was marked. During the last trapping period, 8 nutria (4 juvenile females and 4 adult males) were marked and 4 animals (2 juvenile females, 1 juvenile male, and 1 adult female) were recaptured a total of 7 times. Age determination was in accordance with the findings of Atwood (1950): all animals with a total length greater than 29.5 inches were considered to be adults. Total lengths at initial marking varied from 23.3 inches (a juvenile male) to 36.1 inches (an adult female); 54% were less than 29.5 inches, that is, were juveniles. Insufficient data were obtained

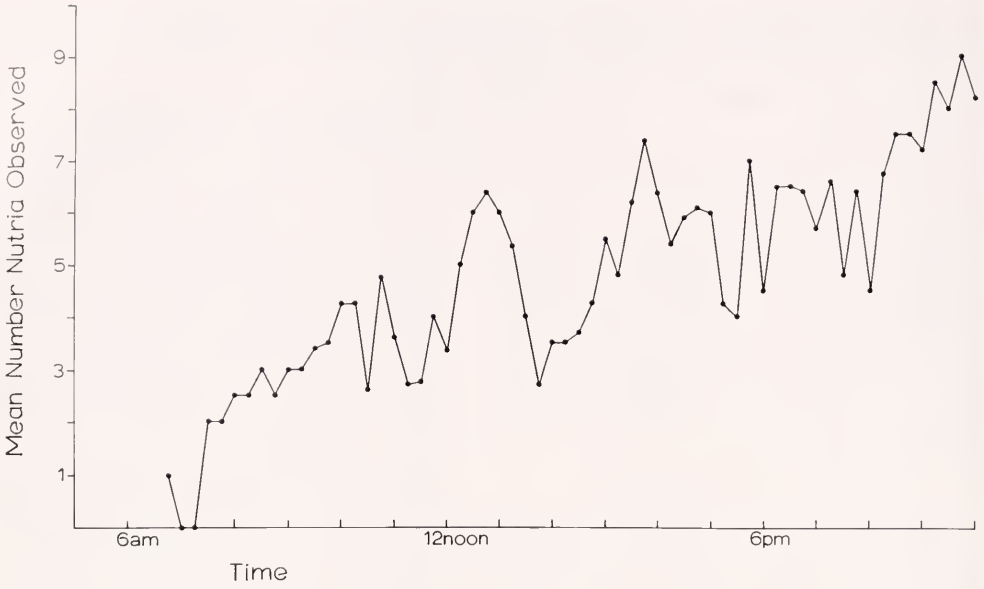

Figure 1. Mean number of nutria observed at different hours of the day.

from recaptures to determine any growth increments.

Recaptures were low. The nutria became trap-shy very rapidly, particularly if the traps were placed on land. One individual was recaptured 7 times, but 7 other nutria were retrapped less than 4 times each.

Only observations on nutria with field markers were recorded. Of the 28 nutria marked, 5 were never seen again, 13 were seen only once, and 7 others were seen on 5 or more separate occasions. The low number of sightings may have been due to the sloughing of field markers during the study. Thus, many of the animals originally marked may actually have been present but not recognized.

Activity

Nutria were active periodically throughout the day and night. Activity (based on the number of animals seen at any given time) peaked at noon, late afternoon, and late evening (Fig. 1). No observations were made of predawn activity. Chabreck (1962) found that activity was highest during the night, peaking just before sunrise. On the other hand, Norris (1967) reported greatest activity between 1800 hrs and sunset, when nutria were grazing. He observed only a limited amount of activity at night. Increased activity during dawn hours was below the peak amount seen prior to sunset.

Davis and Jenson (1960) reported that in England in cold weather, more nutria were seen in the daytime than usual. This did not appear to be the case at Riverside. The number of animals observed at any given time did not change with temperature, but the type of activity did change. At temperatures up to approximately 27° C, most nutria were seen lying in groups of three or four, sunning or sleeping. The areas chosen for this were generally the same (Fig. 2), but at ambient temperatures above 15.5° C, only those not in bright sunlight were used. At night the major activity changed from sleeping to eating; grooming was rarely observed. At temperatures above approximately 28° C, most nutria were seen eating, with frequent grooming; few were seen sleeping. When the temperature exceeded 34° C, no animals were seen sunning. The nutria spent most of the time grooming, or swimming about, frequently stopping to eat for a short period before swimming again.

Single nutria were rarely observed. Generally, two or more nutria were in the same area; the maximum number seen together

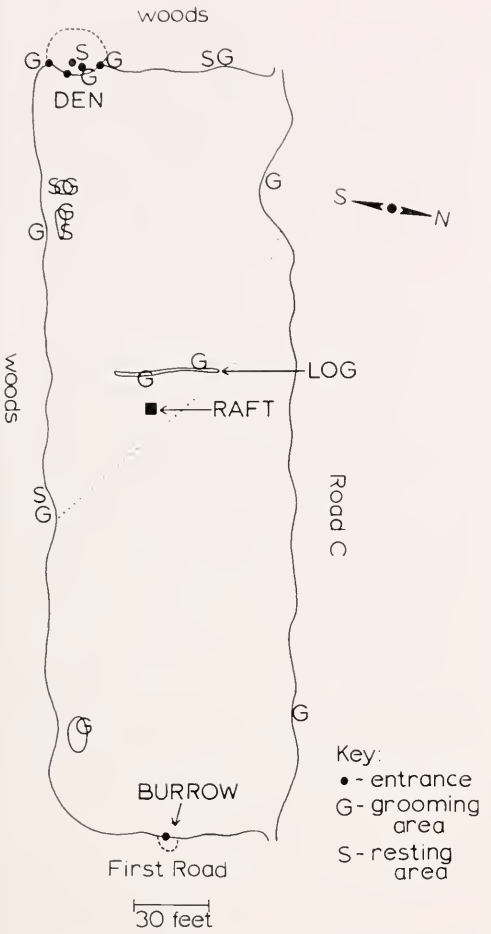

Figure 2. Map of one of the ponds studied showing locations of den entrances, grooming stations, and resting areas. Nutria were seen eating only to the left of the dotted line during the day, but were seen on both sides of the line at night.

was 13. The only exception to this was in the case of several adult males, which were always seen alone.

Movements

Most nutria remained in the study area. Of animals marked, six were observed in the pond adjacent to the original trap site, and three were seen two ponds away (approximately 300 yds) from the original trap site. Only one marked nutria, a large female, was seen further from the study area, at a distance of 600 yds. Adams (1956) and Kays (1956) found that in southwestern Louisiana, daily cruising ranges of nutria rarely exceeded 200 yds and that nutria usually remained in one general area throughout their life. Norris (1967) observed that males ranged farther and most movements out of the home area were made to exploit temporary food supplies. At Riverside, although the only marked animal found outside the study area was a female, a few males were observed wandering alone, at distances up to 200 yds from a pond. These animals were generally grazing on clover.

Movements of nutria within the ponds were closely correlated with the location of duckweed (when the ponds were only partially covered) and with amounts of shade. A preference was always shown for areas of the ponds covered with duckweed, even if the animal was not feeding at the time. At high ambient temperatures, a preference was also shown for shady spots, both in ponds and on land. Nutria suffer from heat prostration if exposed to hot sun for any length of time (Evans, pers. comm.) and were rarely seen in brightly sunlit areas except when moving from one section of a pond to another or when sunning at ambient temperatures below 15.5° C.

Burrows

Nutria lived in large dens in the banks of ponds. A den usually had 3-5 above-water entrances and at least two below-water entrances. The surface of the den was free of vegetation and slickened from the constant activity of household members. Each den complex covered an area 13-18 ft in width, extending into the bank to a depth of 10-13 ft; the height of the top of the den above water varied from 4 ft to 10 ft. Each underwater opening was 8-10 inches in diameter, but above-water entrances were larger (20-30 inches) and often opened into two or more tunnels extending back into the den. Water levels in the ponds dropped 21 inches during May and June, so that many underwater entrances were revealed.

In addition to large dens, there were also many simple burrows with 1-2 openings into the bank close to water level.

Ashbrook (1948) reported that each pair of nutria builds its own burrow. They work in and up until they are well above water level, then a space is cleared and grasses deposited. As the family grows, the burrow

is enlarged, since the offspring from the original pair continue to live in the same burrow. Eventually the burrow, now a den, becomes the home of a large colony. As long as the water supply is sufficient and food plentiful, the colony will remain in the same locality.

Observations of colonies at Riverside agreed with the findings of Ashbrook. Each colony lived in a separate den and spent most of the time in the "home" pond. The number of active dens per pond and the number of individuals in each colony varied. A typical colony consisted of 15-20 nutria and was composed of approximately equal numbers of adults and juveniles and of males and females.

No nests of the type reported by Laurie (1946) were observed, nor did nutria build platforms for sunning, as reported by Atwood (1950). Instead of platforms, nutria utilized floating logs or exposed roots of willow trees located in the water near the pond's edge. The size of the areas varied from 2-3 ft × 6-10 ft and were 2-17 inches above water. Sticks and bits of bark were carried onto these constantly. Most sunning was done in these areas; nutria usually lay in close contact, often partly on top of each other. These areas were also used to some extent as grooming areas (Fig. 2).

Feeding

Feeding appeared to be a major activity of nutria when they were not in the dens. Shady areas were usually chosen for feeding locations. The main diet consisted of duckweed and white clover, but occasionally red maple leaves or bark of willow trees were also eaten. Swank and Petrides (1954) and Atwood (1950) listed many foods consumed by nutria, but neither included duckweed or clover as a major component of the diet. Laurie (1946) noted that in England, nutria barked trees only in captivity.

When eating a maple leaf or a piece of carrot, the nutria sat up on its hind feet and held the food item in its forepaws. Duckweed was eaten with a shovelling motion, both forepaws scooping it into the mouth with a rapid, coordinated motion.

Young nutria ate duckweed in the same manner as adults, except that motions were less well coordinated, much more rapid, and frequently resulted in the young animal getting a face-full, rather than a mouthful, of the aquatics.

Nutria did not form feeding platforms from non-eaten material, as mentioned by Swank and Petrides (1954), nor was food carried to specific feeding stations, as observed by Atwood (1950). Both previous studies were in a marshy habitat, where cattail, bulrush, and other coarse emergents were utilized to a great extent. At Riverside, the ponds contained no such vegetation; the only food carried was an occasional leaf or piece of bark.

As reported by Atwood (1950), whenever possible, nutria utilized floating objects capable of supporting their weight, such as large branches, planks, or logs. If these were not available, shallow or exposed areas along banks were used. In either case, forepaws were left free to hold and manipulate food. Occasionally a nutria would swim around slowly as it ate, paddling with the hind feet, using the tail as a rudder, and scooping duckweed with the forefeet.

Although duckweed was the major component of the diet, clover was also eaten, mainly during hours of darkness. Nutria appeared to select primarily the clover blossoms, leaving leaves and stems, as well as surrounding grasses, untouched.

Grooming

Periodically a feeding nutria would stop and groom itself thoroughly. Young animals stopped to groom more often than adults, but they appeared to be less efficient at removing duckweed from the fur. Grooming always started with much scratching of the sides and stomach by the hind feet. Then the fur was groomed, using the forefeet. The grooming motion is back and forth, rapidly, with the apparent intention of roughing the fur rather than cleaning it; the forefeet were never licked to remove the dirt and duckweed gathered from the fur. Forefeet were used together whenever possible, especially on the head, stomach, and chest. They were used out of phase or only one at a time when grooming the flanks, axilla, and back. Occasionally the teeth were also used, especially on the flanks. Most attention was paid to the abdomen, insides of the flanks, and genitalia. After these areas were thoroughly groomed, the head was cleaned and attention was given to the rest of the body.

Grooming motions appeared to be somewhat stereotyped. Nutria were observed to continue grooming even in a pouring rain, just as if they were dry. A young nutria which was kept in captivity exhibited exactly the same pattern of grooming as animals in the wild, even though it was neither wet nor covered with duckweed. There was never any evidence of mutual grooming; each individual groomed only itself.

Dominance Relationships

A simple hierarchy existed among nutria in the ponds. Within each social group, there was one alpha female and one alpha male. All other animals were equally subordinate; that is, there was no dominance among subordinate members of the group. The alpha female exhibited aggressive behavior towards the alpha male and all subordinate females. The alpha male exhibited aggressive behavior towards all subordinate males and females. Only when the alpha female was in estrus was she submissive to the alpha male.

Dominance was expressed by the alpha animal chasing the subordinate individual. The dominant nutria would swim up very rapidly to a subordinate nutria, sometimes "mooing" several times either before or during the approach. Response in the subordinate animal was generally flight. When the aggressive nutria approached within 5-10 ft, the subordinate animal would dive with a loud splash, swim underwater for a considerable distance (20-100 ft), and reemerge. The dominant animal usually turned 180°at the spot where the other had dived and would begin to feed or groom, paying no attention to any other nutria.

During the course of the study, the dominant female in one of the social groups was displaced by a subordinate female. While the subordinate female was establishing her superiority, she continuously chased all other females and occasionally also chased the males. None of the nutria actually fought with her, although the original alpha female sometimes waited until the last moment before retreating. Dominance was established in 2-3 weeks, but the exact time is not known.

Actual fighting was observed in only four instances. In each case, a male was persistently sexually aggressive toward the alpha female when she was not in estrus. When the male ignored warning sounds (low-pitched "mooing") from the female, she turned on him and they fought literally tooth-to-tooth. During this battle, the only sounds were the gnashing of teeth as the nutria lunged at one another with mouths open, pushing incisors against incisors. Although there appeared to be some attempt to bite the opponent, the main effort was directed at the opponent's teeth. Most fighting took place with heads above water; occasionally the animals rolled underwater and re-emerged splashing as each tried to overpower the other by pushing its head underwater. In the four fights observed, after less than 3 minutes the male exhibited the typical subordinate flight pattern described above.

Whenever a male was rebuffed in his efforts, he spent much time grooming himself and marking the area. Marking consisted of dragging the genitalia (penis extruded) over logs, rocks and any other objects which might be encountered. The male also would raise his tail, back toward the object to be marked or just back up the bank, then urinate backwards in spurts carrying 2-3 ft behind him.

Reproductive Behavior

When the dominant female approached estrus, as judged by the increasingly swollen condition of the external genitalia, both she and the adult males spent more time grooming. Frequently they alternated areas where they sat to groom, so that first a male, then the female, sat on a certain log or part of the bank. Each spent much time sniffing spots where the other had been. But until the female was actually receptive, she continued to chase any aggressive males that came closer than 10-15 ft.

Copulation was not observed but probably took place in the woods. After much vocalization and grooming, the female would follow the male into the woods. Several minutes later when the pair emerged, the female was completely submissive to the male, following him in the pond and being chased when she approached nearer than 3-4 ft to him. There was more vocalization ("mawing") between male and female during this time, always soft and in an alternating chorus.

Receptivity is reported to last 2-3 days (Ashbrook, 1948). At the end of this time, the female again became the dominant member in the relationship.

Care of the Young

There was little care of the young by the mother. All nursing took place inside the den. Frequently when the mother sat in one of the den openings, young crawled over her head and back. Occasionally, the mother nuzzled them, but she never groomed them.

When the young were out of the den, the mother did not stay near them. If one of the young called to her, she answered and sometimes went to it. Always, when the mother came up to one of the young, she first touched noses with it, then either swam on by it or stopped to eat. If a young nutria swam up to the mother, again, touching of noses occurred first. Frequently a young nutria swam around the mother, under her chin, nuzzling her, before it stopped to feed.

Other members of the group also looked after the young. As the young grew more adventurous and became better swimmers, they swam farther away from the den. The young always stayed together or with another member of the colony. Generally a young nutria swam out to a juvenile that was feeding nearby. After touching noses, the young nutria would begin to feed, facing away from the juvenile but still touching its body. Often the juvenile would swim away without the young noticing. The young nutria would continue to eat for a few minutes, then suddenly realize it was alone, and with a startled cry, head back to the den as quickly as possible.

Juveniles often played with young nutria and generally spent much more time with them than did the mother. This may have been because the adult nutria were never observed to play or do much adventuring, whereas young nutria were continually chasing each other, splashing in the water, and investigating everything.

There appeared to be no attempt to protect young from predators. When the mother was frightened, she would run away and leave the young to fend for themselves. Depending on how badly frightened she was, the mother might or might not return for them. It was by frightening away the mother of a litter of five that I managed to catch a baby nutria, which was kept in captivity for four months.

Predation

In the United States, as in England, nutria still have few natural enemies. Man and severe winter weather take the largest toll of nutria in England (Newson, 1966). In the western United States, bobcats and coyotes prey to some extent on nutria, but in the southern United States, predatory birds are the only major predators besides man (Harris, 1956). In the study area at Riverside, garfish (*Lepisosteus* sp.), cottonmouths (*Ancistrodon piscivorous*), and red-shouldered hawks (*Buteo lineatus*) were observed to take young nutria. Only one adult was found killed by another animal, possibly by a bobcat (*Lynx rufus*).

Although at Riverside nutria had few predators except man, they were extremely wary and could disappear very quickly. When mildly alarmed, a nutria would swim behind a log or a branch sticking out of the water. Only its head and back would be above the surface; this was the "watching" position. If a nutria was on land when frightened, it would dash for the pond, enter with a splash, dive, and when it re-emerged, assume the "watching" position described above. As long as the animal was alarmed, it remained completely motionless and in this position easily passed as a log.

When a nutria was frightened to a greater degree, it would dive underwater, slapping the water with its hind feet as it did so. The resounding sound of this splash alerted any other nutria in the area and these also disappeared. Generally the dive lasted 30 sec, and the nutria again emerged at some distant, hidden spot. But occasionally when badly frightened, a nutria would remain submerged for a much greater length of time. Sooter (1943) reported a nutria remained underwater for 3 min 15 sec, but the longest dive observed at Riverside lasted less than 2 min.

No attempt by one animal to protect another was ever observed. Each nutria had to fend for itself, including the young, as discussed earlier.

Acknowledgments

The writer wishes to thank Mr. James Evans, Director of the Nutria Research Station, U. S. Department of Interior, Houma, Louisiana, for his advice on trapping and marking methods and for his generous assistance in the loaning of materials used in the study. Thanks are also due Frank Thomas for aid in collection of data. The study was supported in part by an Environmental Biology Traineeship under the direction of Dr. R. D. Suttkus at Tulane University, New Orleans, Louisiana.

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October 16, 1968

NOTROPIS EDWARDRANEYI, A NEW CYPRINID FISH FROM THE ALABAMA AND TOMBIGBEE RIVER SYSTEMS AND A DISCUSSION OF RELATED SPECIES

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ABSTRACT

Notropis **edwardraneyi,** an endemic cyprinid of the Alabama – Tombigbee River system, is described from 32,493 specimens. A close relative of *N. blennius*, it is restricted to the main channels and larger tributaries below the Fall Line where it is the dominant minnow. *N. edwardraneyi* is compared to *N. blennius* and *N. potteri*, and differs in having a larger eye and in pigmentation. Additional data are given for *N. blennius* and *N. potteri*, and their interrelationship is discussed.

This new species of *Notropis* is of moderate size and presumably is a close relative of *Notropis blennius* (Girard), 1856, and *Notropis potteri* Hubbs and Bonham, 1951. Probably, Hubbs and Bonham's (1951:103) reference to *Notropis blennius* in the Tombigbee River was based on specimens of this new form.

The senior author collected the new species for the first time on 1 August 1957 from below Lock No. 2 on the Tombigbee River. Five years later Meredith May (Blackwell), then a student of Dr. Herbert T. Boschung, requested identification of some specimens taken from the Cahaba River and these proved to be the same as the Tombigbee specimens. An intensive survey of the fishes of the main channel of the Alabama River was started in 1964 and the new form was common, if not the most abundant cyprinid as indicated by the numbers of specimens in the series listed below.

The bulk of the specimens used in this study was obtained by the authors and Dr. Gerald E. Gunning. Some of the remainder were collected by the senior author with the aid of the Environmental Biology Training Program[1] students. We wish to acknowledge assistance in collecting by Dr. C. Robert Shoop, Dr. Sylvia Earle, and Mr. Armand Kuris.

We are indebted to Mr. Ben Stimpson for his generous hospitality. He provided us with a campsite near Choctaw Lake and use of a private boat ramp into the Alabama River for three summers, 1964-1966. This enabled us to obtain samples from the lower part of the Alabama River, a few miles above its junction with the Tombigbee River. During our stay on the Stimpson property, Mr. Elwood Overstreet gave us much valuable assistance.

We are grateful to Mr. B. Frank Wilson, Sr., Executive Vice President of Peoples Bank in Selma, Alabama who made arrangements for our use of the old Crocheron house and property in Cahaba, Alabama as a campsite during the summer of 1964.

Mr. J. Campbell Banks of Columbus, Mississippi made available for our use an area along the Tombigbee River for which we are most grateful.

We would like to take this opportunity to extend our thanks to the biologists and enforcement personnel of the Alabama Conservation Department for their cooperation in all of our biological studies in the State of Alabama. Mr. Carlyle Suttle's cooperation and help deserve special mention.

For permission to examine material housed in the University of Alabama collection, we wish to thank Dr. Herbert T. Boschung. We

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extend our gratitude to Dr. Ernest A. Lachner for making arrangements to examine type-material of *Notropis blennius* in 1958, and other materials during subsequent years; Drs. Reeve M. Bailey and Robert R. Miller for personal efforts to locate series of *Notropis blennius* in the University of Michigan, Museum of Zoology collection for our use as comparative material and Dr. Neil H. Douglas of Northeast Louisiana State College for the loan of some fine series of *Notropis blennius* and *Notropis potteri* from the lower Mississippi River and Red River (in Louisiana) respectively.

We wish to acknowledge our appreciation for the pen and ink illustrations by Miss Betsy Grover and for the photographs by Dr. Clyde Barbour.

Notropis **edwardraneyi**
new species
Fluvial Shiner
(Figs. 1, 4, 7, 9)

The description is based on thousands of specimens (32,493), all of which were taken from the Alabama and Tombigbee drainages.

Material. The holotype, Tulane University number 49485, an adult 57.6 mm in standard length, was collected from the Alabama River at Yellow Jacket Bar, River Mile 129.8 (U. S. Corps of Engineers Navigation Chart, 1958), 1.2 miles down-river from Holly Ferry crossing or 12.5 miles east of Pine Hill, Wilcox County, Alabama, on 8 March 1967, at 2245 to 2345 hours, RDS 4097, by R. D. Suttkus and G. E. Gunning.

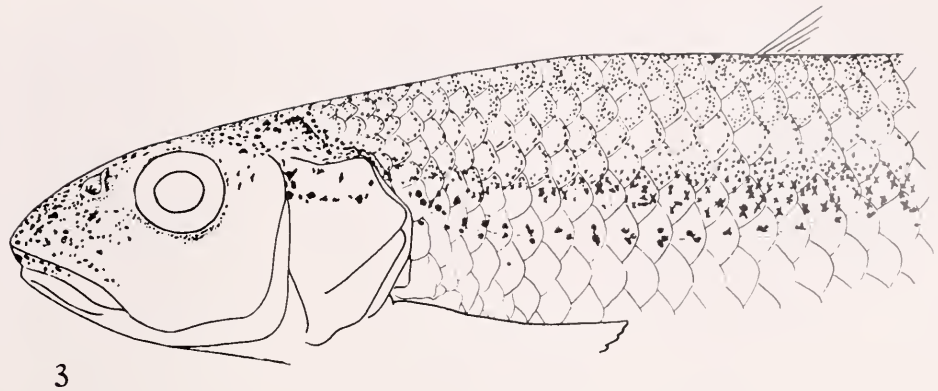
Paratypes: Taken with the holotype were 8,224 paratypes (22.1-56.0 mm in standard length) which were distributed as follows: TU 44028 (7,324 specimens); United States National Museum, USNM 202435 (100); Cornell University, CU 52941 (100); University of Michigan, Museum of Zoology, UMMZ 187475 (100); Academy of Natural Sciences of Philadelphia, ANSP 109424 (100); Museum of Comparative Zoology, MCZ 45878 (100); Stanford University, SU 66551 (100); University of Kansas, Museum of Natural History, KU 12674 (100); University of Alabama, UAIC 2791 (100); and Field Museum of Natural History, FMNH 74294 (100). Other paratopotypes (7,551) were taken 7-8 April 1966 at 2340-2422 hr, (TU 40303, 1020: 19-62); 28 June 1966 at 2227-2308 hr, (TU 40925, 85: 24-52); 1 July 1966 at 1945-2100 hr, (TU 41400, 390: 23-59); 5 August 1966 at 1645-1710 hr, (TU 41726, 16: 12-23); 4 October 1966 at 2200-2235 hr, (TU 41618, 33: 19-40); 19 December 1966 at 2135-2215 hr, (TU 42737, 5630: 19-57); 31 May 1967 at 2150-2230 hr, (TU 46802, 223: 24-55); 7 August 1967 at 2110-2215 hr, (TU 47361, 49: 18-46); and 26 September 1967 at 2155-2250 hr, (TU 47924, 105: 18-53).

Other paratypes (11,773 specimens), all taken from the main channel of the Alabama River from Watts Bar, 3.5 mi above Cahaba, River Mile 204.5, downstream to the Choctaw Bluff area, River Mile 45, are as follows: TU 33381 (1613, 27-65), Dallas Co., Watts Bar, 29 June 1964, Royal D. Suttkus 3515; TU 35243 (236, 24-52), Dallas Co., old ferry landing across river from Cahaba, 27-28 June 1964, RDS 3508; TU 35269 (314, 25-55), Dallas Co., old ferry landing across river from Cahaba, 28 June 1964, RDS 3512; TU 47822 (85, 16-47), Wilcox Co., Hurricane Island, River Mile 166.5, 19 Aug. 1967, RDS 4193; TU 47838 (75, 18-46), Wilcox Co., St. Johns Bar, River Mile 164.8, 19 Aug. 1967, RDS 4192; TU 47762 (143, 20-50), Wilcox Co., Lower Canton Bar, west bank, River Mile 156.7, 18 Aug. 1967, RDS 4190; TU 47781 (9, 16-43), Wilcox Co., Lower Canton Bar, east bank, River Mile 156.7, 18 Aug. 1967, RDS 4191; TU 47515 (306, 17-50), Wilcox Co., Hobbs Bar, River Mile 149.5, 18 Aug. 1967, RDS 4189; TU 40293 (297, 16-54), 7 Apr. 1966, RDS 3857; TU 40900 (289, 24-54), 28 June 1966, RDS 3918; TU 41695 (83, 8-24), 5 Aug. 1966, RDS 3945, TU 41608 (284, 18-56), 4 Oct. 1966, RDS 4011; TU 42731 (470, 19-50), 19 Dec. 1966, RDS 4065; TU 44011 (175, 17-62), 8 Mar. 1967, RDS 4096; TU 46783 (202, 16-41), 31 May 1967, RDS 4143; TU 47346 (64, 21-51), 7 Aug. 1967; TU 47909 (152, 18-47), 26 Sept. 1967; RDS 4202, all from Wilcox Co., Evans Upper Bar, River Mile 135.8; TU 41711 (29, 10-17), 5 Aug. 1966, RDS 3946; TU 47477 (89, 22-45), 9 Aug. 1967, RDS 4186, from Wilcox Co., Evans Lower Bar, River Mile 133. TU 46796 (395, 26-54), Wilcox Co., new bar above Yellow Jacket Bar, River Mile 130.1, 31 May 1967, RDS 4144; TU

Figures 1 and 2. 1 (top) *Notropis edwardraneyi*: lateral view of a paratype (TU 44028) S.L. 54.8 mm, T.L. 71.0 mm. 2 (bottom) *Notropis blennius*: lateral view of topotype (TU 43167) S.L. 54.2 mm, T.L. 69.4 mm.

41732 (19, 15-22), 5 Aug. 1966, RDS 3949; TU 41632 (92, 20-46), 4 Oct. 1966, RDS 4013; TU 47374 (86, 19-42), 7 Aug. 1967, RDS 4179; TU 47936 (39, 13-58), 26 Sept. 1967, RDS 4204; all from Wilcox Co., Reeves Bar, River Mile 128.5. TU 40320 (491, 18-52), 8 Apr. 1966, RDS 3859; TU 40940 (226, 27-57), 28 June 1966, RDS 3920; TU 41745 (63, 14-46), 5 Aug. 1966, RDS 3950; TU 41639 (187, 18-47), 4 Oct. 1966, RDS 4014; TU 42746 (687, 21-56), 19 Dec. 1966, RDS 4067; TU 44029 (94, 21-53), 9 Mar. 1967, RDS 4098; TU 46819 (43, 15-42), 31 May 1967, RDS 4146; TU 47387 (168, 21-36), 7-8 Aug. 1967, RDS 4180; TU 47968 (230, 20-51), 27 Sept. 1967, RDS 4207; all from Wilcox Co., Tait Bar, River Mile 122.4; TU 40335 (243, 22-61), 8 Apr. 1966, RDS 3860; TU 40950 (109, 25-63), 29 June 1966, RDS 3921; TU 41755 (12, 20-48), 5 Aug. 1966, RDS 3951; TU 41655 (119, 19-40), 5 Oct. 1966, RDS 4015; TU 42759 (900, 16-54), 19-20 Dec. 1966, RDS 4068; TU 44045 (461, 18-45), 9 Mar. 1967, RDS 4099; TU 46830 (32, 29-38), 31 May - 1 June 1967, RDS 4147; TU 47396 (33, 20-44), 8 Aug. 1967, RDS 4181; TU 47980 (108, 15-48), 27 Sept. 1967, RDS 4208; all from Wilcox Co., Wilcox Bar, River Mile 120.3.

TU 41761 (9, 28-45), 5 Aug. 1967, RDS 4182; TU 41666 (147, 19-44), 5 Oct. 1966, RDS 4016; TU 47408 (475, 16-48), 8 Aug. 1967, RDS 4182; TU 47994 (65, 19-46), 27 Sept. 1967, RDS 4209, all from Wilcox Co., Ohio Bar, River Mile 111.6; TU 41772 (151, 14-53), 6 Aug. 1966, RDS 3953; TU 41670 (301, 16-41), 5 Oct. 1966, RDS 4017; TU 47420, (173, 18-49), 8 Aug. 1967, RDS 4183; TU 48012 (232, 17-48), 27 Sept. 1967, RDS 4210, all from Monroe Co., Stein Island, River Mile 107.5; TU 41791 (22, 11-17), 5 Aug. 1966, RDS 3954; TU 47491 (24, 24-47), 10 Aug. 1967, RDS 4187, from Monroe Co., St. James



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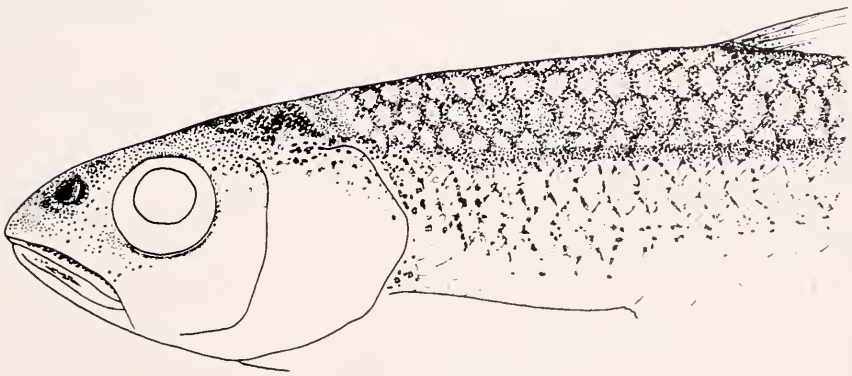

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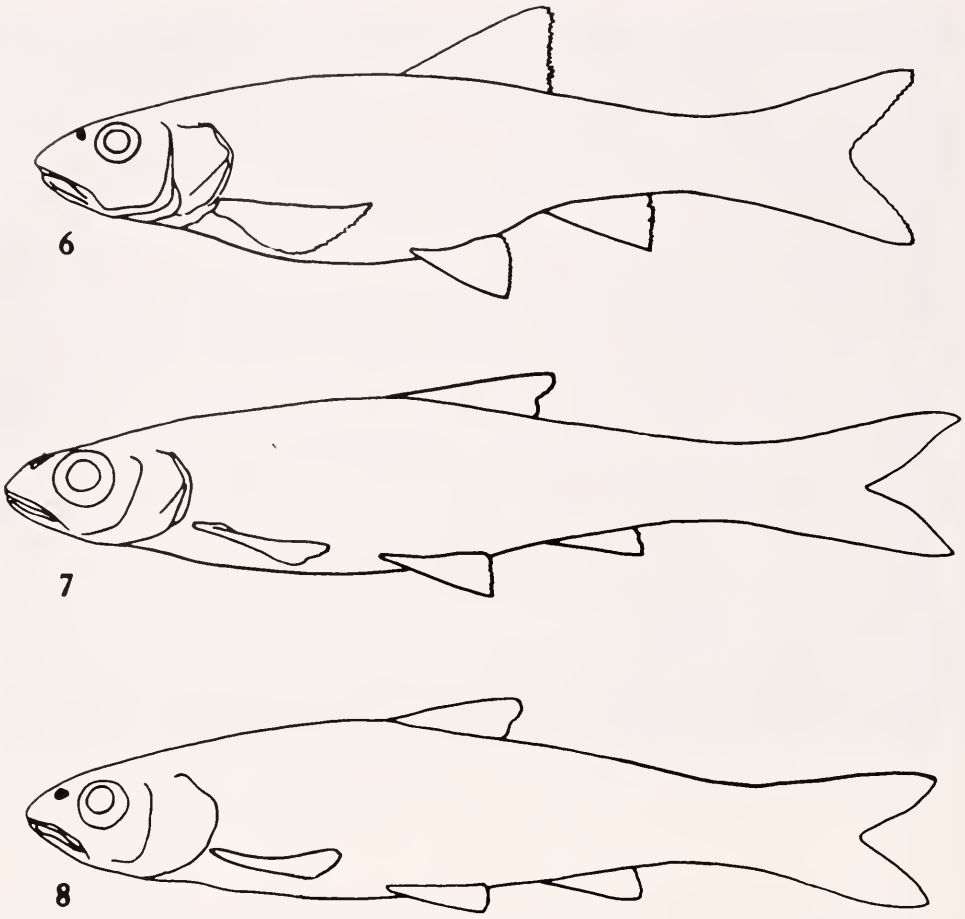
Figures 3-5. 3 (top) *Notropis potteri* (NLSC 5357) S.L. 46.7 mm, T.L. 60.1 mm. 4 *Notropis edwardraneyi* (TU 44028) S.L. 48.9 mm, T.L. 62.3 mm. 5 *Notropis blennius* (TU 43167) S.L. 48.8 mm, T.L. 61.6 mm.



Figures 6-8. 6 *Notropis potteri* (NLSC 5357) S.L. 46.7 mm, T.L. 60.1 mm. 7 *Notropis edwardraneyi* (TU 44028) S.L. 48.9 mm, T.L. 62.3 mm. 8 *Notropis blennius* (TU 43167) S.L. 48.8 mm, T.L. 61.6 mm.

Bar, River Mile 104: TU 41797 (4, 18-27), 5 Aug. 1966, RDS 3955; TU 47435 (229, 15-48), 8 Aug. 1967, RDS 4184, from Monroe Co., Bates Bar, River Mile 99; TU 47452 (134, 22-55), 8 Aug. 1967, RDS 4185, Monroe Co., Haines Island, River Mile 96; TU 41813 (10, 18-41), 6 Aug. 1966, RDS 3957; TU 47499 (16, 30-47), 17 Aug. 1967, RDS 4188, from Monroe Co., Silver Creek Bar, River Mile 87.7; TU 41823 (1, 22), 6 Aug. 1966, RDS 3958, Monroe Co., Mouth of Limestone Cr., River Mile 80.1; TU 35323 (28, 25-33), 2 July 1964, RDS 3519, Clarke Co., Choctaw Bluff, River Mile 45.

Other material, 1297 specimens. Tombigbee R.: TU 40497 (7, 40-48) 10 Apr. 1966, RDS 3865, Miss., Monroe Co., 3.9 mi W of Amory, Hwy 278; TU 34614 (32, 35-58), 9 Sept. 1964, RDS 3583; TU 37585 (25, 42-60), 6 May 1965, RDS 3663; TU 39420 (15, 26-43); TU 40162 (4, 25-43); TU 40217 (12, 20-45); TU 40489 (49, 26-60); TU 48758 (127, 26-53), all from Miss., Lowndes Co., 9.3 mi NW of Columbus, ½ mi above Hwy 50; TU 48837 (30, 30-49), Miss., Lowndes Co., 9.3 mi NW of Columbus, ½ mi below Hwy 50; TU 48867 (758, 20-36), Ala., Pickens Co., 0.7 mi W of Pickensville; TU 16124 (6, 34-39), Ala., Choctaw Co., 5.5 mi SE of Pennington, below Lock No. 2; UAIC 2593 (145, 30-62), Pickens Co., at Vienna; UAIC 1470 (4, 31-46), Sumpter-Greene

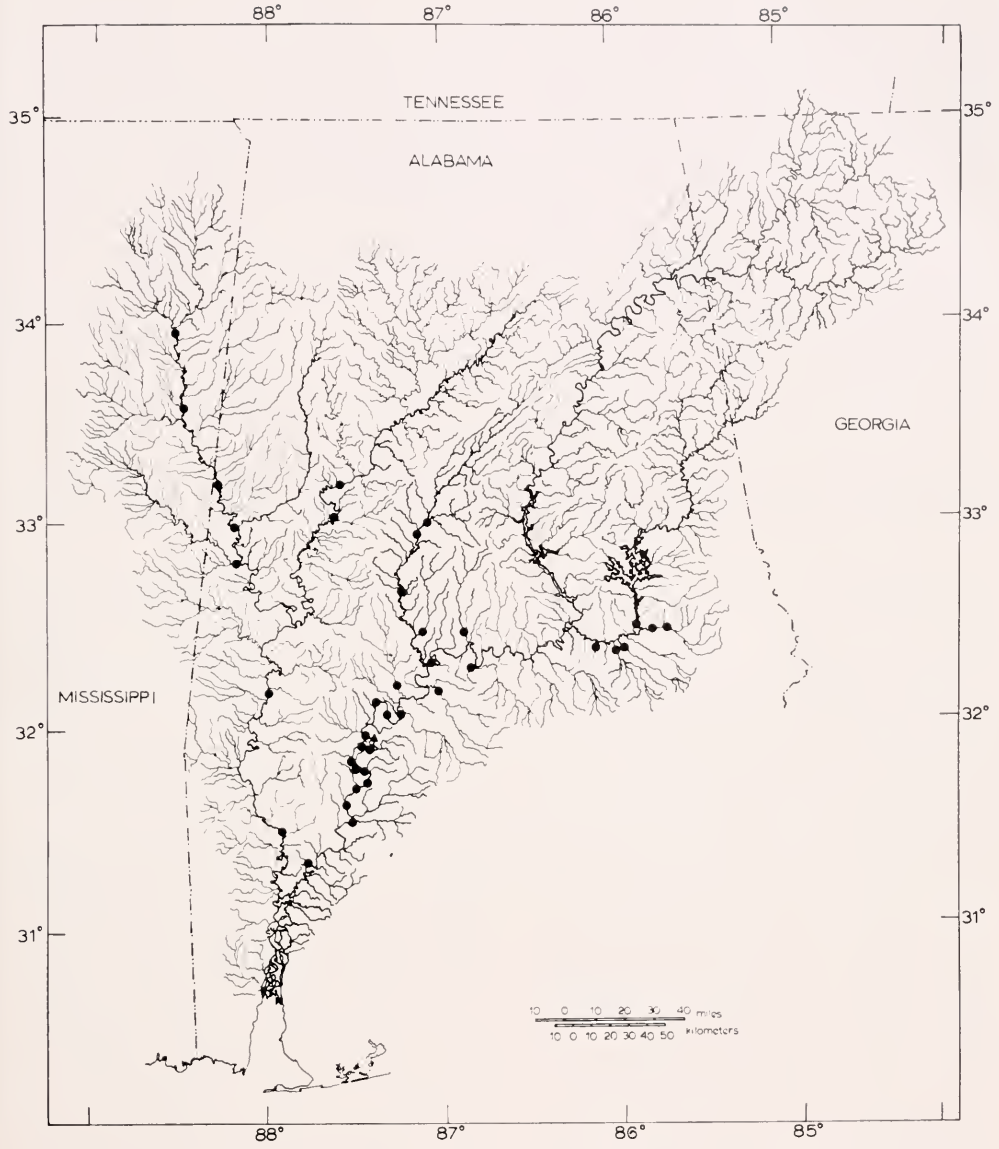


Figure 9. Distribution of collection sites of *Notropis edwardraneyi*. Triangle symbol indicates type-locality.

Cos., Noxube Cr., 1 mi N of mouth; UAIC 2475 (12, 34-42), Clarke Co., 300 yds below Hwy 43 at Jackson.

Black Warrior River: TU 43332 (14, 23-34), 22 Dec. 1966, Glenn H. Clemmer 518, Ala., Tuscaloosa Co., 0.5 mi S of Northport, below dam; UAIC 889 (346, 29-51); UAIC 1056 (217, 31-62); UAIC 1060 (156, 31-46); UAIC 1264 (2, 42-43); UAIC 1502 (235, 20-50); UAIC 1594 (7, 35-44); UAIC 1595 (77, 23-54); UAIC 1608 (36, 28-57); UAIC 1647 (184, 29-56); UAIC 1648 (58, 29-54); UAIC 1694 (193, 28-55); UAIC 1791 (20, 30-52); UAIC 1935 (287, 26-54); UAIC 2032 (276, 25-54); UAIC 2033 (52, 32-51); UAIC 2515 (678, 25-55), all from Tuscaloosa Co., below Oliver Lock and Dam at

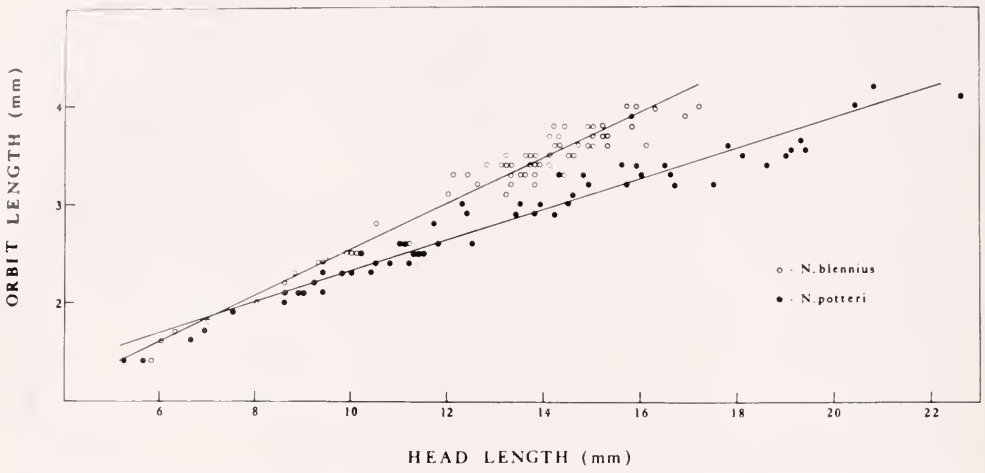


Figure 10. Relation of orbit length to head length in *Notropis blennius* (TU 22422, TU 43167, TU 43174) and *Notropis potteri* (TU 4936, TU 42395).

Tuscaloosa; UAIC 1570 (255, 17-47), Tuscaloosa Co., bar above mouth of Big Sandy Creek.

Cahaba River: TU 35134 (127, 39-45), 26 June 1964, RDS 3505; TU 37698 (13, 45-54), 11 May 1965, RDS 3671, all from Perry Co., 1 mi W of Sprott, off Hwy 14. TU 34055 (14, 39-46), Bibb Co., 8 mi N of Centreville, Hwy 27; TU 35090 (5, 40-44), Bibb Co., 2.1 mi N of Centreville, off Hwy 5; TU 29893 (3, 50-51); TU 30099 (9, 40-50); UAIC 962 (11, 37-52); UAIC 1437 (24, 36-47), 1 mi W of Sprott.

Tallapoosa R.: UAIC 1281 (3, 40-49), Elmore Co., 1.5 mi S of Thurlow Dam, Tallassee; UAIC 1514 (13, 40-47), Macon Co., Uphapee Cr. NW Tuskegee on Hwy 199; UAIC 1516 (29, 40-62), Macon Co., Uphapee Cr., 0.2 mi N Franklin; UAIC 1368 (7, 41-46), Macon Co., Cubahutchee Cr. on Interstate 85, E of Montgomery; UAIC 1234 (38, 36-51), Montgomery-Macon cos., Line Cr. on Interstate 85, E of Montgomery; UAIC 1232 (14, 39-48), Montgomery Co., trib. on Wells Ferry Rd. near Mt. Meigs Station.

Other tributaries: TU 40457 (15, 28-37), 9 Apr. 1966, RDS 3868, Dallas-Autauga cos., Big Mulberry Cr. 10.1 mi E of Selma, Hwy 14; TU 35066 (21, 32-46), Dallas Co., Oakmulgee Cr., 7.2 mi NW of Selma, Hwy 14; TU 35193 (6, 31-42); and TU 35187 (4, 32-39), Dallas Co., Pine Flat Cr. (Six-Mile Cr.) 6 mi S of Selma, Hwy 41; TU 32455 (1, 30), Wilcox Co., Bear Cr. 3.1 mi NW of Lower Peach Tree, Hwy 1; UAIC 2403 (245, 19-55), Dallas-Lowndes Cos., Old Town Cr., ½ mi NW Benton on US 80; UAIC 2366 (12, 24-36), Dallas Co., Cedar Cr., at Hwy 41, 4 mi S of Jct with Hwy 28; UAIC 2392 (11, 25-39), Dallas Co., Bogue Chitto Cr., about 5 mi N of mouth.

The following material was used for comparison with the new species: *Notropis blennius,* USNM 67, lectotype (so designated by Suttkus, 1958: 308), 55.9 mm in standard length, Arkansas River near Ft. Smith, collected by Dr. Shumard; USNM 171791 (syntypes, recataloged as paratypes on 27 June 1958) 5 specimens 50.5-64.0 mm in standard length (see Hubbs and Bonham, 1951: 103); TU 43167 (332: 13-60), Ark., Yell Co., Arkansas River at Dardanelle, Ark. Hwy 7 crossing, 1 February 1967, RDS 4080, Suttkus and Kenneth Relyea; TU 43174 (579: 27-65), same locality as for RDS 4080, 2 February 1967, RDS 4081; TU 22422 (365: 17-50), Ark., Arkansas Co., Arkansas River at Pendleton's Ferry, Ark. Hwy 1 crossing, 23 October 1959, RDS 2851, Suttkus, Myrna Andersson, Bangalore I. Sundararaj; UMMZ 180500 (16: 28-34), Manitoba, Seine River, T10, R3E, S34, 18 August 1955, J. J. Keleher; UMMZ ACC. 1947: XI: 28 (113: 31-58) Iowa, Muscatine Co., Mississippi River at Fairport, Miss. River Survey, 15 June 1946;

TU 19296 (20, 17-57), Ind., Posey Co., Wabash River at old dam, about 4 mi SW of New Harmony, 28 August 1958, RDS 2744, Suttkus and Bruce B. Collette; TU 19356 (12, 22-61), Ind., Posey Co., Wabash River on west side of old dam, 2.5 mi S of New Harmony, RDS 2746, Suttkus, Collette, Dowell, Pugh; TU 43053 (15, 23-48), Ark., Crawford Co., Arkansas River 0.25 mi downstream from old Fort Smith bridge, 25 January 1967, KR-Ark 3, Relyea and Reimer; TU 48248 (856: 18-60) La., Madison Parish, Mississippi River across from Vicksburg, Miss., at U. S. Hwy 80 bridge, 11 October 1967, RDS 4236, Suttkus and Clemmer; TU 47644 (1: 53), La., Rapides Parish, Red River at River Mile 100 (U.S. Corps of Engineers Navigational Chart, 1958) 25 August 1967, RDS 4200, Suttkus and Clemmer; NLSC 5356 (105: 37-57), La., Concordia Parish, Mississippi River at Natchez, 1 to 4 miles north, 25-26 July 1966, Louisiana Wildlife and Fisheries Commission; Northeast Louisiana State College 5441 (19: 37-58), La., Concordia Parish, Mississippi River, 1 to 4 miles north of NLSC 5374 (37: 30-55), La., East Carroll Natchez, Miss., 25-26 July 1966, LWFC; Parish, Mississippi River at Lake Providence, 27 July 1966, LWFC; NLSC 5506 (31: 27-60), La., East Carroll Parish, Mississippi River at Lake Providence, 27 July 1966, LWFC; NLSC 5367 (47: 22-63), La., East Carroll Parish, Mississippi River at Lake Providence, 27 July 1966, LWFC; UAIC 1830 (99, 24-59), Mo., Mississippi Co., T22N, R17E, Sec. 6, Mississippi River 17 mi SE East Prairie, 14 August 1963, W. L. Pflieger and Robert Hentges; NLSC 5654 (43: 23-43), Ark., Jefferson Co., Arkansas River at Pine Bluff; NLSC 5574 (40: 20-46), Ark., Jefferson Co., Arkansas River at Pine Bluff; TU 19022 (2, 16-22), Ky., Jefferson Co., Ohio R about opposite 38th St. in Louisville, just below K and I RR. bridge; TU 2242 (3, 43-46), Okla., Noble Co., Skeleton Cr.; TU 13831 (6, 26-54), Okla., Noble Co., Salt Fork, 7 mi S of Ponca; TU 15543 (35, 27-54), Okla., Wagoner Co., Verdigris R. at Okay bridge, T16N, R19E, S19, TU 10250 (7, 29-43); TU 15637 (311, 20-52); TU 14877 (143, 29-49); TU 15611 (90, 18-49); TU 15471 (9, 27-50); TU 39666 (3, 34-41); all from Ark., Pope and Yell cos., Arkansas R. at Dardanelle, Hwy 7; TU 43164 (113, 17-45), Ark., Arkansas Co., Arkansas R. at Pendleton Ferry crossing, 11.3 mi NE of Dumas, Hwy 1; TU 48267 (39, 16-61), La., West Baton Rouge Par., Mississippi R., ¼ mi above US Hwy 190 bridge at Baton Rouge along west bank; TU 16786 (4, 24-43), La., St. Charles Par., Mississippi R. flood pools in front of Bonnet Carre Spillway dam at Norco.

Notropis potteri, TU 42251 (71: 20-58), Red River at River Mile 97, 6 mi downstream from Alexandria, 9 November 1966, RDS 4039, TU 42304 (46: 16-51), Red River at River Mile 86, 17 mi downstream from Alexandria at Ryland Revetment, 9 November 1966, RDS 4043, TU 42395 (130: 17-58), Red River at River Mile 96.5, half mile downstream from Hudson Revetment, 23 November 1966, RDS 4049, TU 47536 (666: 13-52), Red River at River Mile 81.2, 25 August 1967, RDS 4194, TU 47649 (529, 11-48), Red River at River Mile 100, 25 August 1967, RDS 4200, Rapides Parish, La., Suttkus and Clemmer, NLSC 5352 (483: 18-68), La., Bossier Parish, Red River 11 miles north of Bossier City, 8-12 August 1966, K. Burnside and J. Brantley, NLSC 5357 (505: 17-56), La., Red River Parish, Red River at Coushatta, 8-12 August 1966, LWFC; NLSC 3700 (371: 24-51), La., Rapides Parish, Red River north of Alexandria, 6 April 1966, LWFC; NLSC 3839 (1851: 22-50), La., Rapides Parish, Red River above Alexandria, 5 April 1966, LWFC; NLSC 7297 (46: 15-36), La., Natchitoches Parish, Red River 15 miles SE of Natchitoches; NLSC 7409 (54: 18-47), La., Red River Parish, Red River at Coushatta; NLSC 124 (36: 14-32), La., Concordia Parish, Red River at Acme; NLSC 5442 (38: 26-46), La., Rapides Parish, Red River above Alexandria; NLSC 3393 (570: 18-45), La., Bossier Parish, Red River at Beene Place, Sec 7-T18N-R13W; NLSC 5351 (305: 18-58), La., Red River Parish, Red River at Coushatta; NLSC 4966 (50: 23-60), La., Red River Parish, Red River at Coushatta, 1-2 miles north of bridge; NLSC 3291 (257: 18-58), La., Bossier Parish, Red River at Beene Place, 3-5 miles N of Bossier City; NLSC 4607 (262: 12-65), La., Bossier Parish, Red River at Beene Place, Hwy 3, Sec 7-T18N-R13W; NLSC 3840 (627: 23-

TABLE 1
Measurements of *Notropis* in thousandths of standard length. Mean value is given below (in parentheses) range of variation.

Species	*edwardraneyi*		*blennius*		*blennius*
Catalog Number	TU 49485 Holotype	TU 44028 Paratypes	USNM 67 Lectotype	TU 43167 Topotypes	UMMZ ACC. 1947:XI:28
River System and State	Alabama, Alabama			Arkansas, Arkansas	Mississippi, Iowa
Standard length (mm)	57.6	51.0–55.2* (52.9)	55.9	51.9–58.2* (54.3)	43.3–58.1* (48.8)
Predorsal length	524	491–533 (514)	509	504–528 (517)	501–525 (510)
Dorsal origin to caudal base	493	491–523 (507)	518	482–520 (503)	487–523 (508)
Dorsal origin to occiput	299	275–312 (299)	318	295–320 (307)	300–319 (309)
Prepelvic length	516	497–524 (510)	501	491–515 (505)	485–525 (509)
Anal origin to caudal base	297	290–310 (303)	304	297–334 (313)	304–328 (317)
Body depth	224	211–231 (224)	234	201–238 (219)	215–251 (233)
Body width	144	142–164 (152)	–	147–165 (158)	146–169 (156)
Caudal peduncle length	217	198–219 (211)	227	195–231 (216)	213–229 (222)
least depth	101	100–107 (103)	113	101–111 (106)	103–123 (112)
Head length	271	253–275 (262)	266	255–281 (267)	256–276 (264)

TABLE 1 (Continued)

Species	*edwardraneyi*		*blennius*		*blennius*
Catalog Number	TU 49485 Holotype	TU 44028 Paratypes	USNM 67 Lectotype	TU 43167 Topotypes	UMMZ ACC. 1947:XI:28
River System and State	Alabama, Alabama			Arkansas, Arkansas	Mississippi, Iowa
Head depth	168	162–176 (168)	168	155–172 (165)	162–176 (170)
Head width	154	145–162 (152)	143	142–156 (151)	134–155 (146)
Interorbital width, least fleshy	94	83–96 (89)	93	94–104 (99)	90–107 (98)
Snout length	87	76–89 (82)	79	78–92 (84)	71–83 (78)
Orbit length	90	79–91 (86)	75	60–67 (64)	60–70 (65)
Upper jaw length	80	67–82 (77)	93	76–90 (83)	77–91 (84)
Suborbital width	29	27–39 (30)	27	24–32 (29)	26–34 (29)
Dorsal fin, depressed length[1]	210	215–239 (226)	214	204–225 (213)	203–236 (216)
Anal fin, depressed length[2]	153	156–178 (164)	161	156–169 (162)	153–174 (162)
Pectoral fin length	188	189–207 (194)	191	180–209 (196)	180–203 (189)
Pelvic fin length	154	145–168 (156)	150	142–156 (149)	145–154 (150)

[1] measured to end of anterior lobe [2] measured to end of posterior lobe * based on ten specimens

Table 2
Measurements of *Notropis* expressed in thousandths. Mean value is given below (in parentheses) range of variation.

Species	*edwardraneyi*	*blennius*	*potteri*
River System	Alabama	Arkansas	Red
Catalog Numbers	TU 44028	TU 43167	NLSC 3700, 5352, 5357
Number of Specimens	50	50	50
Standard length (mm)	44.0–55.5 (50.5)	45.9–60.0 (52.4)	41.8–57.1 (47.8)
Head length/Standard length	251–276 (263)	207–294 (268)	259–305 (285)
Interorbital/Head length	312–372 (336)	347–413 (374)	324–400 (354)
Snout/Head length	267–333 (307)	282–342 (312)	281–333 (307)
Orbit/Head length	308–363 (333)	229–273 (249)	199–248 (223)
Upper jaw/Head length	267–323 (299)	285–348 (320)	320–382 (347)
Postorbital/Head length	369–436 (402)	441–482 (466)	467–530 (498)
Orbit/Interorbital	886–1102 (992)	589–755 (667)	558–714 (631)
Orbit/Snout	978–1250 (1086)	706–943 (799)	643–833 (727)
Orbit/Upper jaw	1023–1228 (1114)	674–868 (781)	545–743 (644)
Orbit/Postorbital	727–907 (828)	478–579 (535)	381–508 (448)

51), La., Rapides Parish, Red River above Alexandria; Other material all from Red R., Rapides Parish, La., collected by the authors with Dr. Gerald E. Gunning and Jayson S. Suttkus: TU 42229 (61: 17-50), TU 47669 (100: 12-42), River Mile 105, 2 mi above Alexandria; TU 42244 (63: 17-42), TU 45178 (22: 17-30), River Mile 100, 3 mi below Alexandria; TU 45172 (2: 20-23), TU 47628 (22: 15-40), River Mile 97; TU 42267 (51: 20-53), TU 45163 (14: 19-30), River Mile 96.5, half mile below Hudson Revetment; TU 42277 (30: 20-49), TU 42374 (274: 15-48), TU 45161 (11: 20-32), TU 47608 (86: 13-51), River Mile 94 at Grand Bend; TU 42287 (20: 17-28), TU 42365 (20: 15-54), TU 47584 (220: 13-47), River Mile 90; TU 42345 (73: 16-59), TU 45140 (6: 21-35), TU 47571 (678: 13-36), River Mile 86, opposite Ryland Board Revetment; TU 42329 (14: 19-46), River Mile 82.7, 1 mi NE of Magda, 20.3 mi below Alexandria; TU 42318 (32: 19-53), TU 45135 (28: 21-35), River Mile 81.5, at Roxana Revetment; TU 47556 (272: 12-40), River Mile 78; also TU 13403 (194: 20-57), La., Natchitoches Par., Red R., 5 mi N of Natchitoches; TU 13362 (124: 22-43), La., Rapides Par., Red R. at Alexandria, Hwy 71; TU 13027 (7: 31-46), La., Concordia Par., Red R. at Acme.

Notropis potteri material from the Brazos R. system in Texas: TU 4936 (70, 28-86), Bosque Co., Brazos R. where trib. enters about 4 mi S Whitney Dam, 8 Apr. 1952, RDS 2278, Suttkus and Anderson; TU 20235 (5: 56-69), Stonewall Co., Double Mountain Fork, 11.3 mi S Aspermont, Hwy 83, 30 May 1959, RDS 2780, Suttkus, Negus, Shoop, Gould; TU 20257 (3: 54-67), Wichita Co., Wichita R., 0.7 mi N Kadane Corner, Hwy 25, 29 May 1959, RDS 2778, Suttkus, Negus, Shoop, Gould: TU 4994 (11: 35-54), Bosque Co., Trib. 4.0 mi S Whitney Dam, 8 Apr. 1952, RDS 2277, Suttkus and Anderson; TU 35613 (6: 14-48), Brazos Co., Brazos R. at Mussel Shoals, 17 July 1964, RDS 3540, Env. Biol. Class; TU 5013 (1: 52), Williamson Co., San Gabriel R., 6.5 mi E Georgetown, 18 Apr. 1952, RDS 2282, Suttkus and Anderson.

Methods of counting and measuring de-

Table 3
Total number of vertebrae in three species of *Notropis*.

Species Drainage	34	35	36	37	38	N	$\bar{X}$
edwardraneyi							
Alabama R., Ala.	18	105	8			131	34.9
blennius							
Seine R., Manitoba			4	12		16	36.7
Mississippi R., Iowa			6	9		15	36.6
Wabash R., Ohio R., Ind.			12	10		22	36.4
Arkansas R., Ark.	1	4	47	26		78	36.2
Mississippi R., La.			11	6	1	18	36.4
Totals	1	4	80	63	1	149	36.4
potteri							
Brazos R., Tex.		4	17	2		23	35.9
Red R., La.		11	66	12		89	36.0
Totals		15	83	14		112	36.0

edwardraneyi (TU 34614, 35269, 35323, 37698, 40320, 40497)
blennius (UMMZ 180500; UMMZ Acc. 1947:XI:28; TU 19296, 19356; TU 22422, 43053, 43167; TU 48248)
potteri (TU 4936; TU 42251, 42304, 47536, 47649)

scribed by Hubbs and Lagler (1958) were followed except for number of scale rows before the dorsal. The counts given represent the number of rows crossing an imaginary diagonal between the origin of the dorsal fin and the pectoral girdle, just above the anteriormost lateral line scale.

Diagnosis. A moderately stocky shiner of medium length (largest specimen of 32,493 examined was 65 mm in standard length); usually 34 lateral line scales, often 33, occasionally 35; number of vertebrae usually 35, occasionally 34, rarely 36; eye very large, supralateral in position; diameter of orbit greater than length of upper jaw, about one-third length of head, nearly equal to fleshy interorbital distance (sometimes greater but more often slightly less than interorbital distance) and averages more than three-fourths of the postorbital distance.

Description. Notropis edwardraneyi is similar to *Notropis blennius* in many proportions (Table 1) but differs primarily in the size of the orbit (Tables 1 and 2, Figs. 1, 2, 4, 5, 7, and 8). In profile the snout is blunter in *edwardraneyi* than in *blennius* and the eyes are more dorsal in position. The position and large size of the eye is reflected in the proportionally smaller interorbital distance. As shown in Tables 1 and 2, the relationship of the length of head to the standard length is almost identical in *edwardraneyi* and *blennius,* but when the relationship of orbit to standard length is considered there is no overlap. Thus, in addition to the effect on size of interorbital distance, the large eye in *edwardraneyi* averages greater than three-fourths of the postorbital distance, whereas the diameter of orbit averages slightly more than half the postorbital distance in *blennius.* The orbit is nearly always greater in diameter than length of snout in *edwardraneyi* and never as great (average about three-fourths snout length) in *blennius.* The mouth is smaller in *edwardraneyi* and the diameter of orbit is always greater than length of upper jaw. *Notropis blennius* has the opposite combination, i.e., larger mouth and smaller orbit that is never as great as length of upper jaw (about three-fourths).

Notropis edwardraneyi typically has a pharyngeal tooth formula of 2, 4-4, 2. An examination of 50 sets revealed 47 specimens with 2, 4-4, 2; two with 1, 4-4, 1 and one with 1, 4-4, 2. All specimens used were taken from TU 33381. For comparison the same number of *Notropis blennius* (TU 22422, Arkansas River) and *Notropis potteri* (NLSC 3839, Red River) were examined. The examination of pharyngeal teeth of *blennius* resulted in 46 specimens with 2, 4-4, 2; two with 1, 4-4, 2; one with 1,

Table 4
Number of lateral line scales for three species of *Notropis*.

Species and Drainage	32	33	34	35	36	37	38	39	40	41	N	x̄
edwardraneyi												
Tombigbee R.		8	13								21	33.6
Black Warrior R.		5	9								14	33.6
Big Mulberry Cr.		3	11	1							15	33.9
Cahaba R.		3	15	2							20	33.9
Alabama R.,												
Watts Bar		7	18	5							30	33.9
Hobbs Bar		2	16	2							20	34.0
Yellow Jacket Bar		6	17	7							30	34.0
Choctaw Bluff Bar	2	17	12								31	33.3
Totals	2	51	111	17							181	33.8
blennius												
Seine R., Manitoba				8	7	1					16	35.6
Mississippi R., Iowa				39	65	5	0	0	0	1	110	35.7
Mississippi R., Missouri			2	20	26	2					50	35.6
Arkansas R., Arkansas			2	22	31	3	2				60	35.7
Mississippi R.,												
Lake Providence				14	26	10	0	1			51	36.0
Vicksburg			2	18	23	6	1				50	35.7
Natchez			4	17	19	10					50	35.7
Red R., Louisiana							1				1	
Totals			10	138	197	37	4	1	0	1	388	35.7
potteri												
Red R.,												
Bossier City, La.			4	14	2						20	34.9
Coushatta, La.				9	4	2					15	35.5
Alexandria, La.			3	7	5						15	35.1
Totals			7	30	11	2					50	35.2

4-4, 1; and one with 3, 4-4, 2. Of the 50 specimens of *potteri,* 48 had 2, 4-4, 2 pharyngeal teeth and two had 1, 4-4, 2 pharyngeal teeth. The total number of vertebrae, including Weberian apparatus (4) and urostylar vertebra (1), was as follows: 18 specimens with 34, 105 with 35, and eight with 36 vertebrae (Table 3). Except on the belly, the scales are rather large over most of the body, including the nape. The head and breast are naked. Although we found that most of the specimens of *blennius* had complete squamation of breast (Hubbs and Bonham, 1951: 105), we observed that some were incomplete either by having the extreme anterior portion naked or by having only a few scattered, partially imbedded, scales on the breast. The scales on the belly are progressively smaller anteriorly and some of the anteriormost are imbedded. The lateral line is complete and slightly decurved anteriorly. There are 32 to 35 scales (some slightly elevated) along the lateral line (modally 34, frequently 33) (Table 4), 20 to 26 (typically 22 to 25) rows around body before dorsal and pelvic fins (Table 5), scales are not crowded before dorsal, 13 to 15 rows before it on a diagonal to opercle (Table 6). The number of scale rows around the caudal peduncle was determined for 181 specimens. Nearly all (177) had five rows above and five rows below the lateral line (5-2-5). One specimen had five above and only four below (5-2-4), two specimens had 6-2-5, one had 7-2-5. The same 181 specimens had the following fin ray counts: 180 specimens had 8 principal dorsal fin rays, one had 7 rays; 178 had 7 principal anal fin rays, three had 8 rays; 175 had 19 principal caudal fin rays, two had 20 rays, three 18 rays and one had 16 principal caudal fin rays; 1 specimen had 12 left pectoral rays, five had 13 left pectoral rays, 57 had 14 rays, 93 had 15 rays, and 25 had 16 rays (Table 7); four specimens had 13 right pectoral fin rays, 62 had 14 rays, 92 had 15 rays, 22 had 16 rays, and one had 17

Table 5
Body circumference scale row counts for three species of *Notropis*.

Species and Drainage	20	21	22	23	24	25	26	27	28	29	30	31	32	N	$\bar{x}$
edwardraneyi															
Tombigbee R.	1	0	14	3	2	1								21	22.4
Black Warrior R.			1	4	8	0	1							14	23.7
Big Mulberry Cr.			1	3	10	1								15	23.7
Cahaba R.			5	11	4									20	22.9
Alabama R.,															
Watts Bar			3	11	9	5	2							30	23.7
Hobbs Bar			5	7	7	1								20	23.2
Yellow Jacket Bar		1	3	13	10	2	1							30	23.4
Choctaw Bluff Bar		1	2	2	13	10	3							31	24.2
Totals	1	2	34	54	63	20	7							181	23.5
blennius															
Seine R., Manitoba				3	8	2	3							16	24.3
Mississippi R., Iowa			1	5	49	19	12	10	12	2				110	25.1
Mississippi R., Missouri					15	11	17	6	1					50	25.3
Arkansas R., Arkansas					21	15	9	10	5					60	25.4
Mississippi R.,															
Lake Providence					10	11	11	8	10	0	0	0	1	51	26.0
Vicksburg			1	0	19	12	14	3	1					50	25.0
Natchez				2	8	8	12	11	8	0	1			50	26.0
Red R., Louisiana										1				1	
Totals			2	10	130	78	78	48	37	3	1	0	1	388	25.4
potteri															
Red R.,															
Bossier City, Louisiana							2	6	8	2	2			20	27.8
Coushatta, Louisiana							3	3	7	2				15	27.5
Alexandria, Louisiana						1	4	2	5	2	1			15	27.4
Totals						1	9	11	20	6	3			50	27.6

right pectoral rays (Table 8). The typical number of pelvic fin rays was 8 on either side but two specimens had 9 on each side and five specimens had only 7 on each side (Table 9).

The mouth is terminal to slightly subterminal, upper lip varies from slightly exceeding snout to slightly subequal. The lower lip is subequal to or included by upper lip; maxilla is slightly curved. The mouth is oblique and does not quite reach to the anterior border of orbit. Anterior lobe of dorsal fin is longest in depressed position, its posterior margin straight or slightly falcate. The posterior lobe of the moderately falcate anal fin is typically longer than anterior lobe in the depressed position of fin.

Nuptial tubercles are well developed on pectoral fins only in adult males. There is a single row along the upper surface of the anterior ray. Proximally there is a single row on the second to the seventh or eighth ray but a double row more distally on these same rays. The double row of tubercles is separated at the fork of each ray, one row continues out each of the two branches. Both males and females have fine tubercles on the head, more on the former.

Coloration. As is typical with many large river forms *Notropis edwardraneyi* is a silvery shiner without any striking colors. The entire ventral surface of head and body is devoid of pigment except for a few deeply imbedded melanophores along the base of the anal fin and along the ventral portion of caudal peduncle. The dorsal and dorsolateral portion of body is pigmented (Fig. 4) with small chromatophores. These chromatophores are concentrated on the central portion of most scales and the concentrations have a well defined posterior border which is submarginal to the posterior margin of the scales. Thus many scales in the dorsolateral area of the body have a pronounced light margin as illustrated in Figure 4. The lower margin of the above described area is bordered by a band of

Table 6

Predorsal scale row counts between dorsal fin and opercle in three species of *Notropis*.

Species and Range	13	14	15	16	17	18	19	20	N	$\bar{x}$
edwardraneyi										
Tombigbee R.	1	12	8						21	14.3
Black Warrior R.	1	8	5						14	14.3
Big Mulberry Cr.		9	6						15	14.4
Cahaba R.		14	6						20	14.3
Alabama R.,										
Watts Bar		18	12						30	14.4
Hobbs Bar		12	8						20	14.4
Yellow Jacket Bar	1	16	13						30	14.4
Choctaw Bluff Bar	3	21	7						31	14.1
Totals	6	110	65						181	14.3
blennius										
Seine R., Manitoba			5	10	0	1			16	15.8
Mississippi R., Iowa		1	44	44	16	3	2		110	15.8
Mississippi R., Missouri		1	20	20	6	3			50	15.8
Arkansas R., Arkansas			33	24	2	1			60	15.5
Mississippi R.,										
Lake Providence			24	18	6	2	0	1	51	15.8
Vicksburg		1	20	22	4	2	1		50	15.8
Natchez		1	30	15	2	2			50	15.5
Red R., Louisiana							1		1	
Totals		4	176	153	36	14	4	1	388	15.7
potteri										
Red R.,										
Bossier City, Louisiana		1	10	6	2	1			20	15.6
Coushatta, Louisiana		1	3	9	2				15	15.8
Alexandria, Louisiana		3	9	2	1				15	15.1
Totals		5	22	17	5	1			50	15.5

larger chromatophores. This band extends posteriorly along the caudal peduncle to the base of the caudal fin. There is a faint disjunct basicaudal, wedge-shaped spot in some specimens. Many juveniles and young have such a spot. The area just above and below the lateral line sensory pores is sparsely pigmented. Some specimens contained in the University of Alabama collection from Black Warrior River system are rather densely pigmented. The moderate-sized melanophores are scattered (Fig. 4) and typically are not concentrated immediately above and below the lateral line pores nor are they aligned with scale margins. There is a fine (sometimes only a single line of chromatophores) to moderately developed pre- and postdorsal, median stripe. The top of the head is rather uniformly pigmented, the pigmentation extending only to the upper part of the almost immaculate opercle and cheek. There is a narrow ring of pigment around the lower rim of the orbit and a concentration of pigment in front of orbit (preorbital bar hardly visible with unaided eye). The extent of pigmentation on lips is variable. In some specimens both lower and upper lips are immaculate, other specimens have just the anterior portion of upper lip pigmented and in others both lips are pigmented but none has pigment on chin or isthmus. The pelvic and anal fins (a few specimens from Black Warrior River have pigmentation along rays of anal fin) are without pigment; the caudal and dorsal fins lack pigment on the membranes but have it along the rays. Pigmentation on the pectoral fins is sparse, progressively diminishing from anterior to posterior rays. There is usually a single file of chromatophores along the leading and posterior edge of the first pectoral ray and only along posterior margins of succeeding rays. The chromatophores are more widely spaced in the files, and the lengths of the files are shorter progressively toward the posterior rays of the

Table 7
Number of left pectoral fin rays in three species of *Notropis*.

Species and Range	11	12	13	14	15	16	17	N	x̄
edwardraneyi									
Tombigbee R.			1	7	10	3		21	14.7
Black Warrior R.			1	5	8			14	14.5
Big Mulberry Cr.				6	7	2		15	14.7
Cahaba R.				5	9	6		20	15.0
Alabama R.,									
Watts Bar				4	20	6		30	15.1
Hobbs Bar			1	9	8	2		20	14.5
Yellow Jacket Bar				11	16	3		30	14.7
Choctaw Bluff Bar		1	2	10	15	3		31	14.5
Totals		1	5	57	93	25		181	14.7
blennius									
Seine R., Manitoba					9	7		16	15.4
Mississippi R., Iowa				2	17	9	2	30	15.4
Mississippi R., Missouri			2	4	24	17	2	49	15.3
Arkansas R., Arkansas				4	29	23	4	60	15.4
Mississippi R.,									
Lake Providence	1	0	0	6	34	10		51	15.0
Vicksburg			1	9	32	7	1	50	15.0
Natchez			1	11	21	16	1	50	15.1
Red R., Louisiana						1		1	
Totals	1	0	4	36	166	90	10	307	15.2
potteri									
Red River,									
Bossier City				3	7	8	2	20	15.4
Coushatta				1	8	5	1	15	15.4
Alexandria				2	6	5	2	15	15.5
Totals				6	21	18	5	50	15.4

fin. Usually the posterior half to two-thirds of the fin is immaculate. The peritoneum is silvery with scattered melanophores.

Reproduction. Ripe females were collected from the Alabama River at the abandoned ferry landing across from the town of Cahaba between 2300 and 0045 hours on 27-28 June 1964 (TU 35243). The spawning individuals were taken in moderate current along the bank from over a sand bottom. The water varied from one to two-and-a-half feet deep and was 28 C at the time of capture. Ripe individuals were collected again at the same locality on the following night (June 28) between 2230-2330 hours (TU 35269). The next time that ripe individuals were collected was 6 May 1965, from the Tombigbee River (TU 37585) northwest of Columbus, Mississippi, between 2115-2330 hours. A number of specimens was checked at the time of collection and all proved to be ripe females. These were taken from over gravel or a mixture of gravel, sand and silt in one and a half to two feet of water. The water temperature was 21 C at time of collection. During the following spring the same locality on the Tombigbee was sampled. Distended females collected between 2300 and 2430 hours, 9 and 10 April 1966 (TU 40489) voided eggs only when firm pressure was applied with fingers (squeeze ripe). Water temperature was 15 C at time of collection. Females collected from Tombigbee River 3.9 miles west of Amory on 10 April 1966 between 1120 and 1200 hours (TU 40497) were squeeze ripe also. Water temperature was 15 C and depth of capture, type of associated bottom and current was similar as described for other localities.

On 31 May 1967, many ripe females were taken from the Alabama River at an unnamed bar (River Mile 130.2) and Yellow Jacket Bar, the type locality (River Mile 129.8). The former collection (TU 46796) was obtained between 2123 and 2142 hours and the latter (TU 46802) 2150 to 2230 hours. Water temperature was 24 C at both

Table 8
Number of right pectoral fin rays in three species of *Notropis*.

Species and Range	13	14	15	16	17	N	$\bar{x}$
edwardraneyi							
Tombigbee R.		8	10	3		21	14.8
Black Warrior R.		7	6	1		14	14.6
Big Mulberry Cr.		6	7	2		15	14.7
Cahaba R.		6	10	4		20	14.9
Alabama R., Watts Bar		5	19	6		30	15.0
Hobbs Bar	2	8	8	1	1	20	14.5
Yellow Jacket Bar		10	16	4		30	14.8
Choctaw Bluff Bar	2	12	16	1		31	14.5
Totals	4	62	92	22	1	181	14.7
blennius							
Seine R., Manitoba			11	4	1	16	15.4
Mississippi R., Iowa	1	3	8	16	2	30	15.5
Mississippi R., Missouri	3	6	27	12	1	49	15.0
Arkansas R., Arkansas		2	29	23	6	60	15.5
Mississippi R., Lake Providence		7	31	12	1	51	15.1
Vicksburg		8	34	8		50	15.0
Natchez		11	23	15	1	50	15.1
Red R., Louisiana				1		1	
Totals	4	37	163	91	12	307	15.2
potteri							
Red R., Bossier City		1	8	7	4	20	15.7
Coushatta		1	6	7	1	15	15.5
Alexandria		2	5	7	1	15	15.5
Totals		4	19	21	6	50	15.6

localities. In both areas ripe fish were taken from over gravel in a riffle area as well as from over sand bottom in moderate current. The areas of capture varied from one to two-and-a-half feet in depth. Thus in summary, *Notropis edwardraneyi* was taken in spawning condition during May and June at water temperature ranging from 21 to 28 C.

Range. All specimens were taken from the main channel of the Alabama and Tombigbee rivers and the lower reaches of their major tributaries (Fig. 9). The irregular distribution of *Notropis edwardraneyi* shown on the map is a reflection of the discontinuity of collecting and not discontinuities in distribution.

Geographic Variation. No clines seem to be present in meristic characters, proportions, or pigmentation. Specimens from the extremes of the range as well as from intermediate areas and tributaries were used in making meristic counts. The only notable deviation was the number of lateral line scales in the sample from Choctaw Bluff (Table 4). However, the frequency distribution for Choctaw Bluff specimens and the other distributions for the upstream (more northerly) samples do not illustrate a north-south cline.

Relationships. Notropis edwardraneyi appears to be a close relative of *Notropis blennius* and may represent an off-shoot from *blennius* stock that gained access to the Alabama and Tombigbee systems through a former connection with the Tennessee (Hayes and Campbell, 1900: 131-133; Simpson, 1900: 133-136; Suttkus and Ramsey, 1967: 138). The absence of *edwardraneyi* in the Pascagoula River, Pearl River, and other minor river systems between the Alabama-Tombigbee systems and the Mississippi River would seem to negate an eastward movement of *blennius* stock from the Mississippi River basin to the Alabama-Tombigbee; we believe that the Tennessee River was the most likely route of access in the near geological past. A number of series of *blennius* from various localities along the Mississippi basin and from Manitoba was examined and characteristics compared to determine presence of geographical

Table 9
Number of pelvic fin rays for three species of *Notropis*.

	9–9	9–8	8–9	8–8	8–7	7–8	7–7	8–6	7–2	N
edwardraneyi (TU 33381, 30; TU 35134, 20; TU 35323, 31; TU 37585, 21; TU 40457, 15; TU 43332, 14; TU 44028, 30; TU 47515, 20)	2	3	1	163	3	4	5			181
blennius (UMMZ 180500, 16; UMMZ Acc. 1947:XI:28, 30; TU 43167, 60; TU 48248, 50; NLSC 5356, 32; NLSC 5374, 25; NLSC 5441, 18; NLSC 5506, 20; NLSC 5367, 6)	5	3	3	232	9	0	2	2	1	257
potteri (NLSC 3700, 15; NLSC 5352, 20; NLSC 5357, 15)		3	1	44	1	0	1			50

clines or populations which possessed intermediacies between other *blennius* populations and *edwardraneyi* (Tables 1, 4, 5, 6, 7, 8, 10). Unfortunately, *blennius* material from the Tennessee River was not available for our study. The specimens (UAIC 1830) from the Mississippi River in southeastern Missouri seem to have a larger orbit than any other *blennius* material from more northern or southern localities. However, some specimens (see footnote, Table 10) were in a partially dehydrated condition and accuracy of measurements was not comparable to that for other samples. Excluding the Missouri sample, the other three samples used for Table 10 demonstrate a weak north-south cline, with a slight increase in size of orbit toward the south. No samples examined indicated a population with close affinities (particularly with regard to size of orbit) to *edwardraneyi*. Thus we assume that differentiation occurred primarily or entirely after the stock became isolated in the Alabama-Tombigbee basins, if *blennius* and *edwardraneyi* are indeed close relatives and do not merely represent convergence because of their large river habitat.

Geographical clines are hardly demonstrable for *Notropis blennius* (Tables 1, 4, 5, 6, 7, 8 and 10) especially with regard to meristic characters. Perhaps the only proportions that could be considered as clinal are the diameter of orbit and length of upper jaw in relation to head length (Table 10). These data seem to be in contradiction to those presented by Hubbs and Bonham, 1951: 104 and comparison number 23, on page 107 in which they said *Notropis blennius jejunus* had a larger eye than *N. b. blennius*. However, they said also that in the far north the eye in *jejunus* becomes reduced. Apparently they did not mention the source of their comparative material and so further discussion is unwarranted. The trend toward the south in an increase in length of jaw is in about the same magnitude as the increase in size of orbit. In view of the wide separation of the range in size of orbit of *edwardraneyi* and the most southern samples of *blennius* examined, there seems to be little or no reason to believe that a population of *blennius* with intermediate size orbit exists, particularly in the intermediate geographical area. For the sake of completeness the following data are presented for 258 specimens of *Notropis blennius* (338 less 80 of the series, UMMZ ACC. 1947:XI: 28). One of the 258 specimens had 9 principal dorsal rays, all the rest had 8; two of the 258 specimens had 8 principal anal rays, all the rest had 7; 243 specimens had 19 principal caudal rays, two had 20, ten had 18 and three had 17; 233 specimens had a scale count around the caudal peduncle of 5-2-5, one had 5-2-6, one had 5-2-7, ten had 6-2-5, one had 6-2-6, eight had 7-2-5, two had 7-2-6 and two had 7-2-7.

Notropis potteri was mentioned as an ally of *blennius* by Metcalf (1966: 122) and as a close relative of *edwardraneyi* in our introduction and perhaps is, but it is more distinct from *edwardraneyi* than *blen-*

Table 10
Measurements of *Notropis blennius* expressed in thousandths. Mean value is given below (in parentheses) range of variation.

Locality	Miss. R., Iowa	Miss. R., Mo.	Arkansas R., Ark.	Miss. R., La.
Catalog Number	UMMZ Acc. 1947:XI:28	UAIC 1830	TU 43167	NLSC 5356 NLSC 5441
Number of Specimens	30	50*	50	50
Standard Length (mm)	39.7–58.1 (45.1)	38.0–59.0 (47.6)	45.9–60.0 (52.4)	37.3–58.0 (49.5)
Head Length/S. L.	248–279 (265)	251–280 (265)	207–294 (268)	257–283 (271)
Interorbital/Head Length	342–391 (369)	351–405 (379)	347–413 (374)	328–393 (358)
Snout/Head Length	273–319 (295)	281–326 (301)	282–342 (312)	272–336 (294)
Orbit/Head Length	228–258 (241)	243–287 (262)	229–273 (249)	234–279 (253)
Upper Jaw/Head Length	298–347 (316)	299–339 (318)	285–348 (320)	300–351 (323)
Postorbital/Head Length	474–533 (494)	447–514 (476)	441–482 (466)	437–510 (476)
Orbit/Interorbital	600–731 (655)	620–778 (693)	589–755 (667)	618–828 (708)
Orbit/Snout	730–903 (819)	756–972 (872)	706–943 (799)	735–968 (851)
Orbit/Upper Jaw	700–854 (765)	750–897 (826)	674–868 (781)	711–906 (783)
Orbit/Postorbital	452–533 (489)	491–636 (552)	478–579 (535)	460–615 (532)

* Some specimens in partially dehydrated condition, orbit enlarged because of shrunken condition of fleshy orbital rim.

nius in a number of ways. Perhaps it too was an early offshoot of *blennius* stock that was isolated in the Brazos River and there differentiated. However, we believe a more plausible explanation of relationship is that *potteri* represents a descendent of a different but unknown stock, and that it has converged in a number of ways. Cross (1953: 258) concluded that the presence of *Notropis bairdi* in the Brazos was not attributable to recent introduction as a bait minnow, but that *N. bairdi* is endemic there. In a similar way we differ from Hubbs and Bonham (1951: 107-109) about the presence of *Notropis potteri* in the Red River as a result of bait introductions from the Brazos River. We believe that *N. potteri* gained access into the Red River system through natural means as the result of tributary captures or stream connections. We say this on the basis of the thousands of specimens of *N. potteri* taken from the lower Red River that are available in the Tulane University and Northeast Louisiana State College collections. We do not maintain that these collections of *potteri* from the lower portion of Red River refute the idea of bait introductions especially because most of the mentioned material was collected in recent years. The earliest collections were obtained in 1955 and 1956 from the Red River at Acme, Natchitoches, and Alexandria, Louisiana. At the Natchitoches locality a total of 837 specimens representing 18 species was seined, of which 194 specimens were *potteri*. The Alexandria collection had 15 species and 440 specimens, of which 124 were *potteri*. Unfortunately we do not have collections available at this time from a large intermediate section of the Red River either before or after formation of Lake Texoma. Our collections from the upper Red River system show *Notropis bairdi* to be the dominant ecological representative in that area. If *potteri* could not successfully compete with *bairdi*, this would

Table 11
Number of scales around the body below the lateral line.

	9	10	11	12	13	14	15	N	$\bar{x}$
edwardraneyi	33	63	76	9				181	10.3
blennius	1	11	198	69	54	3	2	338	11.5
potteri			1	6	34	7	2	50	13.1

account for its absence in the upper Red River. Perhaps the reverse is true in the lower Red River where at least we have never taken *bairdi*. The occasional collections of *potteri* from the Red River at Lake Texoma (Riggs and Bonn, 1959: 163) may be a reflection of more collecting effort after construction of the dam, or it may be a result of reinvasion of the area because of the changes in the habitat which are more suitable for *potteri* and other fishes that have been maintaining populations in the continuously flowing lower Red River. Further discussion of natural dispersion versus introduction by man should include *Notropis brazosensis* (= *shumardi*), following Gilbert and Bailey, 1962, and *Notropis oxyrhynchus* (Miller, 1953: 33-34). Such a discussion was not planned for this paper. However, an additional remark with regard to man's introduction versus natural occurrence of *N. potteri* in the Red River is here presented. If man introduced *potteri* it has swamped out and completely, or nearly so, replaced *blennius* in the shallow marginal areas of the lower Red River. *Notropis blennius* may have been displaced to the deeper parts of the channel where it may be present as natural resident populations.

The foregoing remarks are pertinent to the discussion of the relationship of *potteri* and *blennius*. Hubbs and Bonham (1951: 103) reported on a specimen of *blennius* taken from the Red River south of Ada, Oklahoma, by George A. Moore and J. M. Paden. Moore thought that it represented a bait introduction and perhaps this is true. A single specimen of *blennius* (TU 47644) was collected along with the hundreds of specimens of *potteri* from the lower Red River that are contained in the Tulane University collection. *Notropis potteri* obviously is the dominant ecological representative in the areas that we are able to sample with seines. However, many of the series housed at Northeast Louisiana State College were collected by use of wire trap nets. The single specimen of *blennius* is typical of the species from the Arkansas River in counts, measurements, and pigmentation and was immediately distinguished from *potteri* taken in the same collection. Northeast Louisiana State College collections from the Mississippi River at Natchez, Miss., represent a mixture of *blennius* and *potteri*. Because of the improper preservation (specimens probably died before they were preserved) it is difficult to be certain that introgressive hybridization has or has not taken place. Some specimens (those in better condition) are identifiable as *blennius* and others as *potteri*. Thus we record the presence of *Notropis potteri* in the Mississippi River proper. The collection (RDS 4236) obtained by the authors from the Mississippi River at Vicksburg on 11 October 1967 contained no *potteri* but 856 specimens of *blennius* (TU 48248), none of which resembled *potteri*. Of course this does not prove the absence of *potteri* in the Vicksburg area other than perhaps at the particular time and place of our collection. Collections of *blennius* from the Mississippi River at Baton Rouge and New Orleans, La., apparently do not exhibit any *potteri* traits. Further analysis of the relationship of the two species in the stretch of Mississippi River between Natchez and the mouth of the Red River is deemed impractical at this time. However, the relationship of *potteri* from the Red and Brazos rivers and *blennius* from the Arkansas and elsewhere in the Mississippi River drainage will be discussed.

The ontogenetic changes in *Notropis potteri* are remarkable and are decidedly different from those of either *blennius* or *edwardraneyi*. The size of orbit does not increase at the same rate as increase in length of head (Fig. 10). In specimens of 50 mm standard length the orbit is approximately one-fourth the length of head (Table

2) whereas the diameter of orbit is less than one-fifth the length of head in specimens over 80 mm standard length. For specimens which average about 50 mm standard length (Table 2) the orbit of *potteri* is considerably smaller than that of *blennius* and extremely so in comparison to that of *edwardraneyi*. Though the eye is smaller in *potteri* the interorbital distance is not proportionally so much greater than that in *blennius* because of the higher position of the eyes in *potteri*.

The changes in the shape and length of snout deserve special mention. The young and small juveniles of *potteri* have an extremely sharp-pointed snout (sharper than either *blennius* or *edwardraneyi*) which gradually approximates the shape and relative length of snout of *blennius* and *edwardraneyi* and then at its largest size has the bluntest snout of the three. Obviously larger individuals were under observation when Hubbs and Bonham (1951: 102) remarked upon the similarity of *potteri* to *Semotilus atromaculatus*. Moreover, there is a structural difference between *potteri* and *blennius* which apparently adapts *potteri* for a closer association with the bottom. The pectoral fins project laterally in a rather rigid fashion so that they are seldom seen on their side while flopping in the seine but are usually on their belly. *Notropis blennius* usually shows its side when alive in the net. Numerous field observations disclose that *potteri* lives on the bottom and is usually closely associated with it; however, *blennius* is often observed and taken from mid-depths, off the bottom. Some differences in proportions among the three species under consideration are illustrated in the outline drawings, Figures 6, 7, and 8.

We are in agreement with Hubbs and Bonham (1951: Table VI, 109) on measurements of *potteri* and so did not duplicate or incorporate a set of measurements in our Table 1. *Notropis potteri* tends to be closer to *blennius* than to *edwardraneyi* in most of the scale and fin-ray counts presented in Tables 4-8. *Notropis potteri* averages more scales around the body and usually has 13 or more below the lateral line (Tables 5 and 11). Many of the high counts in *blennius* relate to a high count above the lateral line and not below, the latter count (below) is modally 11.

Hubbs and Bonham (1951: 107) gave a description and comparison of pigmentation of *blennius* and *potteri*. Cognizant of some variability in pigmentation in the three species under consideration, we believe Figures 3, 4, and 5 represent typical patterns. *Notropis potteri* often has an intervening scarcely pigmented area between the lateral line pores with their associated pigmentation and the more dorsal band of large chromatophores. In *blennius* the pigmentation is continuous from the back, down the sides to the lateral line row of scales and often on the scale row below the lateral line.

Again, in order to be more complete, the following are the data for the less variable structures. In 50 specimens of *potteri* from the Red River in Louisiana two had 7 principal dorsal rays, the rest had 8; two had 8 principal anal rays, one had 6, and the rest had 7; two had 18 principal caudal rays, the rest had 19; 20 specimens had 5-2-5 scale rows around the caudal peduncle, 12 had 6-2-5, one had 6-2-6, 11 had 7-2-5, two had 7-2-6, and four had 7-2-7. Other scale and fin-ray counts are given in Tables 4-9, 11.

Etymology. We take pleasure in naming this new form in honor of Dr. Edward C. Raney in recognition of his many contributions to North American ichthyology and his guidance and imparted enthusiasm toward a multitude of students.

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TULANE STUDIES IN ZOOLOGY AND BOTANY

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AGGREGATIVE BEHAVIOR AND HABITAT CONDITIONING BY THE PRAIRIE RINGNECK SNAKE, *DIADOPHIS PUNCTATUS ARNYI*

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Abstract

When ringneck snakes were released in laboratory arenas in which all cover objects presented equalized physico-chemical conditions the snakes were found to follow a multinomial distribution with unequal probabilities of occupancy of each cover object. The resultant clumped distributions are the result of intrinsic aggregative drives which are not based on sexual attraction, as was evident from repeated aggregation formation among either males or females in experiments involving only one sex. Preliminary findings on effects of environmental variations in the experimental arenas indicate that aggregative behavior can be modified, at least by increasing or decreasing the dampness of the substrate.

Persistent use of the same cover object by groups of ringneck snakes indicated that there might be a bias for particular locations in the arenas. Various experimental tests demonstrated that the bias was due to presence of an attractant substance, possibly integumentary, cloacal gland, or excretory in origin, which is deposited by snakes that first frequent the particular cover site. Such sites are herein described as "conditioned habitat." Snakes will seek and return to conditioned substrate even when it is translocated in the experimental arena. Snakes apparently use visual and olfactory and/or vomeronasal sensory perception to locate the conditioned sites and to trail other snakes or locate trails left by the travels of other ringneck snakes.

The advantages of aggregative behavior and habitat conditioning are discussed and compared to denning habits of large snake species.

Introduction

Social behavior in snakes, at least in the form of epideictic display, is very limited. Passive social behavior such as aggregation is a common phenomenon, but studies on factors initiating and affecting aggregative behavior are few and are limited in scope. Reports of snake dens are common in literature, the most exhaustive discussion of the topic being that by Klauber (1956). Denning, of course, is a seasonal phenomenon principally characteristic of large snake species. Aggregation is also common among small secretive species. It may occur in hibernacula during the winter, but is also observed at other times of the year. A comprehensive study of aggregative phenomena in the northern brown snake (*Storeria dekayi*) was reported by Noble and Clausen (1936). Otherwise the reports on aggregation in small snakes have been casual statements about the number of snakes found under a single object, or descriptions of the responses of animals to extremes of temperature, humidity, light, and so forth.

The interpretation of aggregative phenomena must take into account extrinsic and intrinsic factors. The extrinsic factors relate to habitat selection in a varied environment; the intrinsic factors involve instinctive social drive in the absence of alternative physical environments. A seasoned snake collector working in a familiar area

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develops considerable ability to find his quarry. What he is recognizing is habitats and microhabitats and, crudely, the physiological needs of a snake. He also becomes aware that the environment is not uniform and that he is unable to satisfactorily evaluate the distinction between intrinsic and extrinsic factors bringing the snakes into the sites that he searches most exhaustively. The excellent study by Noble and Clausen (*op. cit.*) has provided many instructive clues for recognition of these conditions, but for reasons given below other approaches to the understanding of aggregative phenomena are required.

In the south central United States there are several species of small secretive snakes, generally averaging under 12 inches long and usually found under sheltering objects in the mild, moist spring months. Some species are largely solitary (*e.g., Tantilla gracilis*), others tend to occur singly or in groups of two or three under individual sheltering objects (*e.g., Tropidoclonion lineatum, Carphophis amoenus, Leptotyphlops dulcis, Sonora episcopa*), and one species (*Diadophis punctatus arnyi*) is very gregarious, often occurring in numbers of half-a-dozen or more under a relatively small piece of cover. Additionally, certain stones regularly have small snakes under them, suggesting that optimal conditions must prevail in these microhabitats. Published studies by various authors on the above mentioned species have largely confirmed these impressions.

The distribution of small secretive snakes can, of course, be assumed to be non-random in the field. Since the natural environment is variable the snakes will ordinarily be found under naturally occurring suitable cover items; hence their distribution will not be random with respect to all cover. If all cover objects had equal probability of selection as a cover object by each snake the snakes would be unable, therefore, to select cover objects on the basis of physico-chemical attraction. Under such equalized conditions, three alternative distributions of the snakes appeared possible, given sufficient but not excessive time. The snakes could be distributed as:

1) a multinomial distribution with equal probability of occupancy of each cover site or
2) a uniform distribution or
3) a multinomial distribution with unequal probabilities of occupancy of each cover site.

If the first distribution were observed no social relationships would be likely and distribution could be termed as random. If the distribution were found to be uniform, territorial behavior would be suspected, particularly if only one animal utilized an individual cover item. Finally, if a multinomial distribution with unequal probabilities of occupancy for each disc were observed, there would be evidence of social relationships. The first and third distributions would of course result in aggregations or clumps of the ringneck snakes, but the expectancy of clumps would be greatest in the third type of distribution.

The ringneck snake, *Diadophis punctatus arnyi,* was selected for the present study because of its abundance and its obvious gregariousness. Various reports call the species common, apparently assigning this category to finds of a dozen or so in an hour. Hurter (1911) reported finding 17 specimens under a rock about 24×18 inches. Brennan (1936) reported 14 under a flat rock. Richard B. Loomis (personal communication) knew of one case where 44 were found under a single stone. Loomis and Dundee collected 300 ringnecks, as well as many other reptiles, in one hour on April 30, 1950 in Douglas County, Kansas. On April 11, 1967 Dundee alone collected 238 ringnecks in 50 minutes in Douglas County, Kansas, from an area about 10 feet wide and 400 feet long. This latter collection included all sizes of ringnecks and counts of 15, 12, 11, 9, 9 were recorded from individual stones.

The obvious questions arising from these observations on abundance are (1) were the sites optimum habitat; (2) were individual stones particularly desirable, thus attracting more ringnecks during their wanderings; (3) were the snakes gregarious because there were so few cover objects in relation to the population size; (4) were the aggregations a result of intrinsic drive?

Not all of these questions are immediately answerable, but certain generalizations might be made providing partial answers to some of these questions. First, we can assume that the Douglas County physical setting is an optimum habitat because it regularly har-

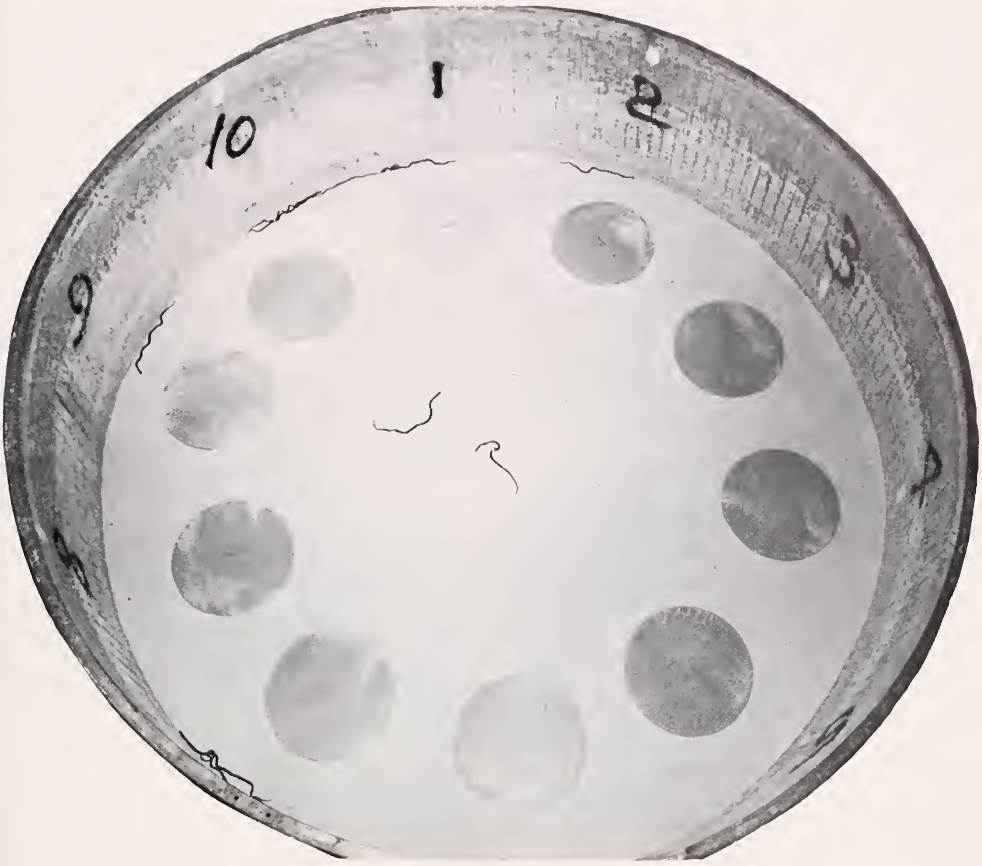

Figure 1. Circular sand-filled arena used for experiments. Snakes seen are ringnecks to show relative size in comparison to the seven-foot diameter of tank and 12-inch diameter discs.

bors large numbers of ringnecks. Second, snakes were found beneath various sizes of stones under which the soil ranged from dry to moist. And third, the stones were loose on the ground or partially embedded. These observations indicate that the microhabitats selected were not markedly restricted. There were many flat limestone slabs that harbored various reptiles or none, but which could have served as cover for ringnecks. Hence we judge that population pressure was not severe. Only laboratory experiments can provide data for an adequate answer to the fourth question and hence the basis for the initial studies of our investigation.

Materials and Methods

The basic design of our experiments derives from the hypothesis that ringneck snakes have intrinsic aggregative drives which may or may not be modified by environmental factors.

Artificial habitats were established in the laboratory by using circular livestock watering tanks seven feet in diameter. The tanks were mounted on platforms equipped with rollers so that they could be rotated at will.

Thirty mm of mason's sand was placed on the bottom to provide a non-packing substrate. The sand could be smoothed to uniform depth.

Circular discs, 12″ in diameter, made of ¼″ plywood and painted gray to simulate limestone were arranged radially concentric to the edge of the tank (Fig. 1). These discs could be rotated by hand, and pressed down to make them lie flush upon the substrate. Loose sand was brushed up around the perimeters of the discs to insure sealing

of any irregularity that might offer easy access to the underside of the discs. The circular tank and circular discs eliminated angles that could provide biased thigmotactic satisfaction. Each disc offered equal conditions for selection as a cover site.

Most experiments were conducted using dry sand. In certain experiments with moist sand as a substrate, Bouyoucos soil moisture blocks from Industrial Instruments, Inc. were buried in the sand at strategic locations. Conductivity in the blocks was measured by a Bouyoucos Moisture Meter, also from Industrial Instruments, Inc. The experimental arenas were kept in a room usually maintained at 75 ± 2°F and humidity of 57 ± 5%.

Only a diffused outside light entered the room by day. Artificial light provided from the ceiling was regulated by an automatic timer to approximate normal day length, but was set to come on after dawn so that no sudden brightening would frighten the snakes.

Experiments were run with adult animals only and almost exclusively with males. The use of males was almost mandatory because of the paucity of females in field collections. Snakes used in experiments were sorted according to sex (double checked by determining presence of anal ridges and hemipenial sheaths in males).

For certain experiments the animals were marked with either brightly colored lacquer or butyrate dope for convenient recognition, thus eliminating the need for handling the snakes. Markings used were yellow, orange, and white neck rings or short dorsal stripes.

Animals were reused for experiments but were fed earthworms between experiments and were permitted to rest for about a week before being placed into arenas again. In certain experiments, particularly those involving dry sand, when snakes were gathered for re-release, water was provided *ad libitum* before release to offset dehydration.

Snakes were released from the center from under an inverted can after they had become quiescent. All releases were made during daylight hours.

Dispersal and distribution of the snakes were determined by daily daytime inspections of the arenas. Procedures included, (1) initial release of snakes and the notation of their locations without handling or displacing them, (2) daily pickup and re-release from the center, (3) daily pickup and re-release after the sand had been gathered, thoroughly mixed, redistributed, and discs washed in detergent and reset, (4) translocation of specific discs and their underlying substrate to other positions in the arena, (5) rotation of tanks to test for possible compass or light orientations.

Results

General Behavior of Snakes After Release

When the inverted can was lifted to release snakes there was little reaction and the animals usually lay quiescent for up to 10 minutes. Eventually one or more animals would begin to glide out from the center. When this movement began it was not unusual for the moving animals to be joined by others so that they appeared to stream out in pairs or triplets. Movement away from the center seemingly was cautious and exploratory but within 15 minutes most snakes were active and gradually edging from the center, though some tended to remain for periods of an hour or more. The snakes often pressed their snouts to the substrate, suggesting the use of olfaction. Their actions suggested that vision, olfaction, and vomeronasal sensing were being employed to enable the snakes to determine where they wished to move. Both vision and olfaction were stated by Noble and Clausen (1936) to be the primary senses used by *Storeria dekayi* to locate their own kind, but a later study by Wilde (1938) suggested that the vomeronasal organ (= Jacobson's organ) rather than olfaction was the effective sensory device. We are conducting experiments to determine if these senses are the major ones used by individual *Diadophis* during their dispersal and search for cover and other *Diadophis*. Eventually the radial dispersal became a concentric one because of the limiting wall of the arena, and snakes ceased to stream in pairs and triplets. Generally most snakes were hidden by day, but when the substrate was smoothed at night numerous tracks could be found the following morning, showing that considerable nocturnal movement had taken place. Snakes that might be abroad in the early morning frequently were under cover when disc checks were made in the early afternoon.

Table 1

Dispersal of ringneck snakes in an arena containing dry sand, 10 twelve-inch discs, 40 male snakes. Ambient temperature 75–76° F. Relative humidity 54–64%. May.

Days after release	Disc											
	1	2	3	4	5	6	7	8	9	10	open	hidden
2	1	1	1	5	6	4	0	5	1	2	14	0
3	0	2	1	2	4	7	0	6	0	2	16	0
4	1	2	0	1	4	14	0	6	0	4	8	0
5	1	2	2	0	4	17	0	4	0	2	8	0
6	1	1	1	2	4	12	0	6	1	2	10	0
7	0	2	0	0	3	24	1	6	0	0	4	0

Access to the underside of discs was accomplished by pressing the snout repeatedly against the perimeter of the disc until the head was pushed under. Only rarely did any snake burrow into the open sand.

Snakes and Substrate Left Undisturbed After Location of Snakes Noted

1. *General statement of hypothesis.*

In our first experiments we assumed that if snakes were released from a central point they would distribute randomly, and that if no aggregative drive existed, snakes would show a random distribution from day to day. A series of experiments was designed to test this hypothesis of random distribution following release. Noble and Clausen (1936) found that aggregations of *Storeria dekayi* could be forced by jostling the cages. They also found that snakes clustered in areas of presumed optimum temperature and humidity when left undisturbed, but if the clusters were disturbed the snakes would break into smaller groups. Thus it was decided that experimental animals should be left undisturbed after release. Initial experiments showed that if discs were lifted gently and the snakes counted quickly there was little evidence of excitement of the animals. After the discs were replaced the snakes were free to move at random.

2. *Results.*

In the first experiment 40 male snakes were collected and released in an arena containing dry sand and 10 twelve-inch discs. The distribution of the snakes was recorded daily. The results of this experiment are given in Table 1.

The chi-square test of the null hypothesis that the distribution was the same for each day was not significant [chi-square, 45 d.f. $= 47.34$ ($p = .35$) (Cramér, 1946, p. 443)]. We concluded that there was no difference in the distributions for the various days. Therefore we decided to pool the snake counts across days to determine an overall distribution of the snakes under the discs. A chi-square of the null hypothesis of equal probabilities of occupancy for each disc by each snake was rejected by the chi-square test (chi-square 9 d.f. $= 274.89$) with probability $< .01$. It was concluded that the male ringneck snakes did not follow a multinomial distribution based upon equal probabilities of disc occupancy in their dispersion in the arena.

The second experiment consisted of releasing twelve female ringneck snakes in an arena containing dry sand and 10 twelve-inch discs. Daily observations were again made. The results of that experiment are presented in Table 2. A chi-square test of the null hypothesis of homogeneous distributions for each of the 6 days was not significant [chi-square 45 d.f. $= 41.16$ ($p = .65$), non-significant]. Therefore, it was concluded that there was no difference in the distributions among the days. Tests of the equality of the probabilities of occupancy for each disc by each snake were then undertaken. Chi-square tests for days 2, 3, 4, 5, 6 and 7 were 44.41, 35.45, 45.16, 90.00, 52.50, and 92.00 respectively. Each of these chi-squares is significant. Therefore we concluded that the probabilities of occupancy for the discs were not the same for each of the 10 discs tested.

The next experiment in this series consisted of releasing 9 female ringneck snakes in an arena containing dry sand with 10 twelve-inch discs (Table 3). The initial

TABLE 2

Dispersal of ringneck snakes in an arena containing dry sand, 10 twelve-inch discs, 12 female snakes. Ambient temperature 75–76° F. Relative humidity 54–64%. May.

Days after release	Disc												
	1	2	3	4	5	6	7	8	9	10	open	hidden	dead
2	0	0	0	0	0	0	0	6	0	5	1	0	0
3	0	0	0	0	0	0	1	7	1	2	0	0	1
4	0	1	0	0	0	0	1	0	5	0	2	0	2
5	0	0	0	0	0	0	0	5	0	0	1	0	3
6	0	0	0	0	0	0	1	3	0	0	0	0	2
7	0	0	0	0	0	0	0	2	0	0	1	1	0

Many tracks under discs 3, 4, 7 on day 2; snakes appear to travel in groups. Never any tracks under 5 or 6 during entire run.

phase of this experiment was a duplication of the previous experiment. The findings were similar. A chi-square test of the null hypothesis of similar multinomial distributions for the various days was not significant (chi-square 30 d.f. = 11.74). Similarly, chi-square tests for days 2, 3, 4 and 5 were 24.00, 24.00, 33.13, and 60.75 respectively. Each of these chi-squares is highly significant (probability $< .01$). Therefore it was concluded as above that the probabilities of occupancy for each of the discs by each snake were not the same.

Additional experiments, while not designed primarily for testing the above hypothesis, did however reveal similar findings. For example, one experiment consisting of the release of 34 male snakes, 20 female snakes, and 2 of undetermined sex in an arena containing moist sand and 14 twelve-inch discs, demonstrated the following results (Table 4). The distributions

TABLE 3

Dispersal of ringneck snakes in an arena containing dry sand, 10 twelve-inch discs, 9 female snakes. Ambient temperature 76.5 ± 1.5° F. Relative humidity 48–58%. June.

Days after release	Disc												
	1	2	3	4	5	6	7	8	9	10	open	hidden	dead
Animals left where found.													
2	0	0	0	0	0	0	1	3	0	4	1	0	0
3	0	0	0	0	0	0	0	3	1	4	1	0	0
4	0	0	0	0	0	0	1	5	0	2	0	0	1*
5	0	0	0	0	0	0	0	7	0	1	0	0	0
Day 5 animals picked up and released from center.													
6	0	0	0	0	0	0	2	2	1	3	0	0	0
7	2	0	0	0	0	0	0	4	2	0	0	0	0
After animals picked up on day 7 arena rotated 180°; animals then released from center.													
8	1	0	0	0	0	0	2	3	0	1	1	0	0
9	0	0	0	0	0	0	0	7	0	0	1	0	0
Discs 3 and 8 and their underlying sand interchanged after pickup.													
10	0	1	0	0	0	0	0	0	5	1	1	0	1#
Discs 9 and 5 and their underlying sand interchanged after pickup.													
11	0	0	3	0	0	0	0	1	0	2	1	0	0
All snakes picked up and replaced with 18 males.													
12	0	3	0	0	0	0	0	0	1	0	14	0	0
13	0	4	1	0	0	0	0	0	1	1	11	0	0

*from disc 7 # from open

TABLE 4

Dispersal of ringneck snakes in an arena containing moist sand, 14 twelve-inch discs, 34 male snakes, 20 female snakes, and 2 of undetermined sex. Temperature 75 ± 3° F. Relative humidity 70–79%. June.

Days after release	Disc																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	open	hidden	dead
Snakes left undisturbed in locations where found.																	
1	1	0	0	4	1	20	5	0	2	2	0	0	3	0	19	0	0
2	1	0	0	3	1	21	5	0	9	0	0	2	1	1	12	0	0
3	1	0	3	3	0	20	1	0	17	1	0	5	0	0	5	0	0
4	0	0	3	11	7	15	5	0	11	2	0	0	0	0	2	0	0
5	0	0	1	10	12	12	6	0	13	0	0	0	0	1	0	0	0
6	0	0	0	16	7	14	6	0	10	0	0	1	0	0	2	0	0
7	0	1	1	13	5	15	6	0	9	1	0	1	0	0	2	0	1
8	0	1	3	11	9	15	5	0	9	1	0	1	0	0	0	0	0
At termination of experiment sand under discs remained slightly moist.																	

from one day to another were heterogeneous (chi-square = 131.61, significant at .05). An examination of the data revealed that only 5 of the discs were persistently occupied and the significance of the test is due to the mobility of the snakes among these discs. The chi-square test for the equality of the probability of occupancy for each of the 14 discs by each snake tested to be highly significant for each day.

In another experiment, designed primarily to test the effects of crowding, the same 56 snakes referred to in Table 4 were released in an arena with dry sand with only 7 twelve-inch discs (Table 5). Again the distributions observed (see days 3 and 4) were not significantly different, chi-square = 2.48. The probabilities of occupancy for each of the discs by each snake were not the same. Chi-square 6 d.f. = 63.07, significant at .01.

In a final experiment (See Table 6), 20 male ringneck snakes were released in an arena containing dry sand and 10 twelve-inch discs. Again strong aggregative tendencies were observed when the snakes were left undisturbed. The distributions of day 2, 3, 4, and 5 did not test significantly different. Chi-square 27 d.f. = 28.33 and again the probabilities of occupancy for the 10 discs tested to be heterogeneous [chi-square 9 d.f. = 286.94, significant at .01].

A random distribution of the snakes was not occurring. Snakes tended to occur in several exceptionally large groups as well as a number of small groups, with a continuous range of cluster sizes being the exception.

Daily Re-Release From Center

1. *General statement of hypothesis.*

As earlier noted we assumed that in the absence of intrinsic aggregative drive snakes released from the center of the arena would disperse randomly. Hence, by gathering snakes each day and re-releasing them after resetting the discs, a new set of independent distributions should be obtained if the snakes were not excited by the daily capture and release. To test this hypothesis a series of experiments was conducted.

2. *Results.*

In the first of these experiments, (See Table 7), 10 male ringneck snakes were released in an arena containing dry sand

TABLE 5

Dispersal of ringneck snakes in arena with moist sand, 7 twelve-inch discs, 34 male snakes, 20 females, and 2 of undetermined sex. Temperature 72.5 ± 1° F. Relative humidity 60–72%. June.

Days after release	Disc 1	2	3	4	5	6	7	open	hidden	dead
	Snakes left undisturbed in locations where found.									
3	7	2	17	12	4	2	2	10	0	0
4	4	1	17	12	8	2	2	10	0	0
	End of day 4 all females and undetermined sex removed; continue with 34 males only, with these being released from center day 4 but left undisturbed where found on subsequent days.									
5	2	1	14	5	2	5	2	0	0	0
6	5	0	7	5	6	4	4	1	2	0
7	4	1	9	5	3	3	5	3	0	0
8	7	0	9	4	3	3	4	4	0	0
	Soil under discs still moist at termination of experiment.									

and 10 twelve-inch discs. The snakes were collected and re-released from the center each day. All of the snakes collected were under disc 3 on the first day and continued to return to this disc after release for 3 successive days.

The results of another experiment, given in Table 8, in which 10 male ringneck snakes were re-released in an arena containing dry sand and 10 twelve-inch discs show that on days 1 through 4, disc 8 was repeatedly sought as cover.

A third experiment (see Table 6, days 6 and 7) in which 20 male ringneck snakes were released in an arena containing dry sand and 10 twelve-inch discs showed simi-

TABLE 6

Dispersal of ringneck snakes in an arena containining dry sand, 10 twelve-inch discs, 20 male snakes. Temperature 76.5 ± 1.5° F. Relative humidity 48–58%. June.

Days after release	Disc 1	2	3	4	5	6	7	8	9	10	open	hidden	dead	
	Snakes left undisturbed in locations where found.													
2	0	0	0	0	7	0	1	0	1	9	2	0	0	
3	0	0	0	0	0	0	0	0	2	15	3	0	0	
4	0	0	0	0	0	0	0	0	3	12	5	0	0	
5	0	0	0	0	1	1	0	0	2	10	6	0	2	(from open)
	After recording day 5 snakes picked up daily and released from center.													
6	2	0	0	0	4	0	1	1	5	4	1	0	0	
7	0	0	0	0	5	0	0	0	2	11	0	0	0	
	After picking up snakes on day 7 tank rotated 180° before release.													
8	2	0	0	0	2	2	0	0	0	10	2	0	0	
9	0	0	0	0	0	0	0	0	3	11	4	0	0	
	Discs 4 and 10 translocated, sand and all, to each others position.													
10	0	0	0	0	0	0	0	0	12	2	4	0	0	
	Discs 3 and 9 translocated, sand and all, to each others position.													
11	0	0	0	0	0	0	0	0	6	4	8	0	0	
	Snakes removed and replaced by 7 females.													
12	2	0	0	0	0	2	0	1	0	1	1	0	0	
13	2	0	0	0	2	2	0	1	0	0	0	0	0	

TABLE 7

Dispersal of ringneck snakes in an arena containing dry sand, 10 twelve-inch discs, 10 male snakes. Release of snakes from center each day. Ambient temperature 74 ± 1° F. Relative humidity 49–55%. July.

Days after release	Disc											
	1	2	3	4	5	6	7	8	9	10	open	hidden
1	0	0	10	0	0	0	0	0	0	0	0	0
2	0	0	10	0	0	0	0	0	0	0	0	0
3	0	0	10	0	0	0	0	0	0	0	0	0
4	0	0	10	0	0	0	0	0	0	0	0	0
Ten males from another experiment released here in place of the original ten.												
5	0	0	9	0	0	0	0	0	0	0	1	0
After pickup of snakes sand from under discs 3 & 8 interchanged; disc 6 placed on old disc 3 site (now sand of 8); disc 3 placed on old disc 6 site (still disc 6 sand).												
6	0	0	0	3	0	0	0	3	0	0	4	0
After pickup sand scrambled and discs returned to original compass positions of 1–10.												
7	0	0	0	1	0	0	0	0	0	0	9	0
After pickup sand scrambled again.												
8	0	0	0	4	0	0	2	0	0	0	4	0

lar results. Discs 5 and 10 were preferred over any of the other discs. A test of the homogeneity of the occupancy distributions was not significant. Chi-square 9 d.f. = 9.66 ($p = 0.35$).

Obviously, the null hypothesis of day to day independence of the distributions was incorrect. The distributions obtained by releasing the snakes from a central point each day were not independent from one day to another. In fact, the snakes congregated under very few discs or all snakes congregated under a single disc. We also observed that on successive days the dispersion time from the center appeared to be more abbreviated and wanderings fewer. A snake arriving near a disc that had been regularly used would tarry near that disc and attempt to burrow under it. Occasionally the snake might move off a short distance, but would soon return to the disc. In these cases olfaction or vomeronasal testing appeared to be the primary sense employed. There did not have to be another snake present under the disc, nor did another snake have to be seen to prompt the return to the disc. These observations along with the previous analysis prompted us to conclude that these data could be interpreted as the result of the trailing phenomenon that was noted by Noble and Clausen (1936). A trail used heavily the first day seemed to be providing a strong sensory stimulus so that on subsequent days snakes followed this trail and came to a particular disc at the terminus of the trail. Once the disc had been used by a number of snakes the sand under it was presumably becoming saturated with some dermal or cloacal secretion or some other "conditioner." We decided that a series of experiments should be designed to determine if the substrate was being "conditioned" so that snakes found that particular portion of substrate particularly attractive.

Habitat Conditioning

"Habitat conditioning" was first examined by introducing a different set of snakes into an arena containing "conditioned" sand. One would hypothesize that if the sand was being "conditioned" the distribution of these snakes would follow the distribution of the snakes that previously occupied the arena. The results of such an experiment are given in Table 7. A chi-square test of the null hypothesis was not significant. Therefore, it was concluded that ringneck snakes are capable of "conditioning" sand.

Next, a group of snakes that had previously been allowed to disperse on an undisturbed basis was tested by daily release from the center. These snakes had demon-

TABLE 8

Dispersal of ringneck snakes in an arena containing dry sand, 10 twelve-inch discs, 10 male snakes. Ambient temperature 74 ± 1° F. Relative humidity 50–56%. July.

Days after release	Disc 1	2	3	4	5	6	7	8	9	10	open	hidden	dead	
	Released from center daily.													
1	0	0	0	0	0	0	0	4	0	0	6	0	0	
2	0	0	0	0	0	0	0	5	0	0	3	0	0	
3	0	0	0	0	0	0	0	9	0	0	1(d)	0	1	(from open)
4	0	0	0	0	0	0	0	7	0	0	2	0	0	
	Scrambled sand after pickup; added a new 10th snake.													
5	0	0	0	1	0	0	0	0	0	7	2(1d)	0	1	(from open)
	Scrambled sand after pickup; added a new 10th snake.													
6	0	0	4	0	0	0	0	0	4	0	2	0	0	
	Left sand intact, no scramble, but snakes released from center.													
7	0	0	0	0	0	0	0	0	7	0	2	0	0	
	Accidentally omitted data on one snake. After recording left snakes where found and sand intact but sprinkled sand around disc 9 heavily with water.													
8	0	0	0	0	0	0	0	0	8	0	1	0	0	
	After recording left snakes where found and gave area around disc 9 a fresh sprinkling.													
9	0	0	0	0	0	0	0	0	8	0	1	0	0	

strated strong aggregative tendencies (see days 1-5, Table 6). The results of this experiment are reported in Table 6 (see days 6 and 7). Although there was some disorientation and scattering by the snakes following the center releases, the distribution did not test significantly different from that of the previous day [chi-square 9 d.f. = 9.66 ($p = 0.35$)].

Substrate and disc translocations.

Further experiments were conducted based upon the hypothesis that if habitat conditioning existed the conditioning substance was a material that could be sensed by olfaction, taste, or vomeronasal receptors. Accordingly we attempted to translocate conditioned substrate by scooping it up and placing it where a similar quantity of substrate had been removed, or by interchanging the substrate from beneath two discs.

The results of the first of these experiments is reported in Table 3 (day 10). Discs 3 and 8 and their underlying sand had been interchanged the previous day. The snakes which had been showing up mostly at disc 8 were now at the immediately adjacent position: apparently they "trailed" to favored site 8, found no conditioned substrate there, and stayed in that vicinity where perhaps some attractant still remained. The next day (day 11) three snakes appeared at position 3. This position had not been occupied in the 10 previous days. On day 10, sand from discs 5 and 9 was interchanged. On day 11 disc 9 was heavily tracked as if the snakes were investigating it. Disc 9 had probably been located via trails leading to it, but in the absence of conditioned sand the snakes did not remain there. Snakes appeared under adjacent discs 8 and 10, probably because some conditioning had developed in that area from previous days.

Table 6 gives more compelling evidence that ringneck snakes respond to conditioned substrate. On day 9, discs 4 and 10 were translocated (sand and discs included). After the release many snakes appeared to start toward the old number 10 position, apparently following old trails. But by the next day no snakes were found under disc 4, even though it occupied the formerly popular site of disc 10. Disc 10, occupying the old disc 4 site, again had snakes, apparently having been found by some wanderers. Numerous snakes occupied position 9, possibly because it had some con-

TABLE 9

Dispersal of ringneck snakes in an arena containing 10 twelve-inch discs, ten male snakes, dry sand. Ambient temperature 74 ± 2° F. Relative humidity 50–57%. Snakes released daily from center and sand scrambled daily after pickup of snakes. August.

Days after release	Disc										
	1	2	3	4	5	6	7	8	9	10	open
1	0	5	0	0	0	0	0	0	0	2	3
2	7	0	0	0	0	0	0	0	2	0	1
3	3	0	0	1	1	0	0	1	3	0	1
4	0	1	3	0	0	1	0	0	4	1	0
5	2	0	0	0	0	0	0	4	1	3	0
6	0	2	0	0	0	1	0	6	0	0	1

ditioning and was next to the original disc 10 location. On day 10, discs 3 and 9 were interchanged (disc and sand included). On day 11, disc 9 was popular, even though it occupied the original site of 3 which had never been used. The results of these translocations present clear evidence that the substrate must retain attractant material.

Therefore, an additional experiment was conducted to identify the respective roles of the sand and disc in the retention of the "conditioner." The results are given in Table 7. On day 5, the sands from beneath discs 3 and 8 were interchanged. Disc 3, from the popular area, was placed on the original site of disc 6, disc 6 was placed on top of the sand from number 8, and disc 8 was placed atop the translocated disc 3 sand. On day 6, conditioned sand from 3 was occupied. Disc 3 (the conditioned disc) was unoccupied and disc 4 next to the old conditioned sand site, was now occupied.

From the foregoing results we concluded that sand is a strong retainer of the conditioning material, whereas painted wooden discs are essentially non-absorbent. Also, snakes are not likely to go to a disc merely because it once covered conditioned sand.

Scrambling of substrate.

The previously described results showed that an undisturbed substrate would produce aggregations of snakes and that snakes seemed to find sites via olfactory, vomeronasal, and visual stimuli. Final evidence that an attractant was present in the preferred sites was provided by picking up all snakes and discs and scrambling the sand thoroughly before smoothing the sand and replacing the discs. The attractant would no longer occur in concentrated form, and a random distribution of the snakes would be expected. Snakes would presumably aggregate due to the aggregative forces discussed previously, but the site of the aggregations would no longer be fixed.

Table 9 shows the results of an experiment in which sand was scrambled daily from the first. No conspicuous aggregations showed up at any specific site but complete randomness did not occur. Aggregations of 3-7 snakes were frequent, reflecting the intrinsic aggregative drive.

Table 7 (days 7 and 8) shows the results of another experiment. After a conditioned substrate was scrambled disorientation of snakes was conspicuous, and numerous individuals were in the open. Similarly in another experiment (see Table 8), an aggregation established under disc 8 for four days was disorganized on days 5 and 6 after the substrate was scrambled on days 4 and 5.

Although these experiments were generally consistent, contradictory results occurred when despite daily scramblings at the ends of each of the first three days, disc 10 remained popular (Table 10). The introduction of a new group of snakes at the end of day four, along with scrambling, did not break this pattern. Strangely enough the aggregation broke up on day 6 though no scrambling had occurred. The significance of this is unclear to the investigators, but it should be noted that these snakes were huddled in the open.

Checks on Extraneous Bias in Arenas

The snakes involved in different experiments did not necessarily select discs at the same compass position for their favored cover. However, there remained the possibility that, during a given experiment, drafts, light variations, etc., could be lo-

TABLE 10

Dispersal of ringneck snakes in an arena containing dry sand, 10 twelve-inch discs, 10 male snakes. Ambient temperature 74 ± 1° F. Relative humidity 49–55%. Snakes released from center each day. July.

Days after release	Disc											
	1	2	3	4	5	6	7	8	9	10	open	hidden
1	0	0	1	0	0	0	0	2	1	5	1	0
	After pickup sand scrambled.											
2	0	0	0	0	0	0	0	4	0	5	1	0
	After pickup sand scrambled.											
3	0	0	0	0	0	0	0	0	0	8	2	0
	After pickup sand scrambled.											
4	0	0	0	0	0	0	2	0	0	7	1	0
	After pickup snakes replaced with 10 males from another experiment. Sand scrambled.											
5	0	0	0	0	0	0	2	0	0	4	4	0
	Sand left intact after pickup.											
6	0	0	0	0	0	0	0	3	1	0	6*	0
	Sand left intact after pickup. Tank rotated 180° before snakes released.											
7	0	0	0	0	0	0	0	1	0	0	7	1
8	0	0	8	0	0	0	0	1	0	0	1	0

* Five snakes huddled near disc 10, the "favored disc."

calized, or that snakes might have some intrinsic tendency for compass orientation. Such effects were checked by simple 180° rotation of the arenas.

Table 3 (days 8 and 9) shows that snakes continued to return to their usual discs, even though the discs were 180° from their old compass positions. Table 6 (day 8) shows a similar return to usual haunts. The day after a 180° rotation (Table 10, day 7), a possible compass orientation appeared. Some snakes were huddled near disc 3, the position of the previously popular disc 8. However, most snakes stayed near disc 10, a disc popular for several days previous. On day 8, a large concentration of snakes at disc 3 represents a return to the compass area closer to the area popular through the days prior to rotation.

Effects of Environmental Modifications

Field observations have indicated that ringneck snakes are usually found at times when the upper strata of soil are moist, or if the immediate surface layers are dry the soil under stones is moist. Therefore, our early experiments were conducted with the arena substrate moist. The substrate was moistened with a sprinkler before setting the discs into position. After several days the exposed soil became dry, whereas soil under the discs retained the "pleasantly moist" feel for a week or more. The term "pleasantly moist" conveys our impression that the soil felt cool to the touch and had a texture associated with dampness. Bouyoucos moisture blocks used in later experiments provided quantitative indices of soil moisture without disturbance of the substrate.

In experiments where the arena was premoistened (see Tables 4 and 5), relatively high percentages of animals were in the open for the first few days of observations. But with the passage of time and the drying of the substrate more animals retreated beneath the discs. This behavior suggested that moist soil provided an optimal habitat, and that as exposed soil dried it became less attractive than the soil beneath the discs. Obviously, another interpretation for this behavior is that snakes find excessive moisture undesirable and thus tend to avoid the high moisture level under the discs.

Field observations have consistently indicated that small snakes are not common under cover objects during very wet and rainy periods. This suggests that there may

TABLE 11

Dispersal of ringneck snakes in an arena containing premoistened sand, 10 twelve-inch discs, 67 snakes of both sexes. Temperature 21 ± 1° C. Relative humidity not noted. Initial release from center, then left where found on subsequent days. Discrepancies in counts due to difficulty of accurate counting of large groups without handling snakes. May–June.

Days after release	Disc													soil under disc	open soil
	1	2	3	4	5	6	7	8	9	10	open	hidden	dead		
2	8	0	0	10	4	0	4	2	7	12	5	15	0	moist	moist
4	13	2	0	9	7	5	9	1	1	17	0	2	1	moist	moist
6	7	1	8	6	7	4	10	1	8	16	0	0	0	moist	dry
8	5	3	8	12	5	2	12	1	6	13	0	0	0	moist	dry
	After recording locations and numbers of snakes sprinkled half with discs 1–5, lifting discs to sprinkle under them.														
10	2	1	1	2	3	8	15	1	11	24	0	0	0	moist	moist 1–5 dry 6–10
11	6	3	0	5	10	8	13	1	7	17	0	0	0	moist	moist 1–5 dry 6–10
12	5	1	6	9	17	6	7	1	6	10	0	0	1	moist	moist 1–5 dry 6–10
13	5	4	12	6	14	3	2	4	3	13	0	0	1	moist 1–5 dry 6–10	moist 1–5 dry 6–10
	After recording locations and numbers of snakes sprinkled side 1–5 but did not sprinkle under discs.														
14	1	0	2	0	4	16	9	5	18	9	1	0	0	moist 1–5 dry 6–10	moist 1–5 dry 6–10
15	3	0	0	3	3	13	8	3	14	19	0	0	0	moist 1–5 dry 6–10	moist 1–5 dry 6–10

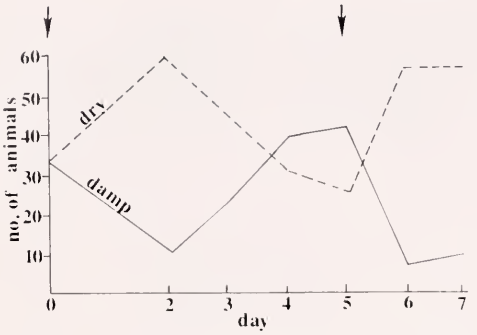

Figure 2. Response of snakes to excessive moisture conditions. On day 0 approximately same number of snakes on both halves of tank. At that time side with discs 1-5 (damp) was sprinkled with water, both around and under discs. On day 5 when both halves of tank had reasonably similar numbers of snakes the area around the discs on side with 1-5 was sprinkled. Side with discs 6-10, labeled dry, had slight moistness under discs until day 5.

on occasion be too much moisture. In nature, of course, recourse to drier subterranean haunts is possible. In our arenas snakes may have selected the surface as an avoidance reaction to excess moisture despite the exposure to daylight because there were no dry deeper strata.

In an experiment involving a large number of snakes in a pre-moistened arena, the animals were well dispersed over the first few days. Only at the start were animals observed in the open or burrowed (Table 11). At the end of day 8 thirty-three snakes were on one side of the tank under discs 1-5 and 34 snakes were on the other side under discs 6-10. At this time the side containing discs 1-5 was re-sprinkled, both around and under the discs. This moistening was followed by a rapid exodus of snakes from the freshly moistened side to the drier side. After four days conditions became similar and both sides of the tank harbored approximately equal numbers of snakes. A second sprinkling of the side with discs 1-5 on day 5 again produced the exodus. Figure 2 graphically depicts the changes of numbers in relation to sprinkling time.

Our data on actual soil moisture levels are limited at this time but they suggest that moisture content of soil is a habitat variable that can lead to modified aggregative behavior.

Table 12

Dispersal of ringneck snakes in an arena containing moist sand, 5 twelve-inch discs, 20 female snakes. Ambient temperature 25 ± 0.5° C. Room non-air conditioned, humidity high but not measured. June.

Days after release	Disc						
	1	2	3	4	5	open	hidden
1	0	0	1	5	0	8	6
2	0	0	0	2	1	2	15
3	0	2	1	0	0	5	12
4	0	0	2	0	0	6	12

Animals removed from burrows at end of experiment. Six animals clustered in one group, three in another group, and three in a third group. Soil in burrows "pleasantly moist." All groups between discs 2 and 3.

In experiments conducted in a room without air-conditioning evaporation from exposed soil was almost nil. Table 12 shows results from one such experiment. Numerous animals remained in the open but many others burrowed into the soil. Burrowing might provide a desired level of darkness as well as moisture. Even while burrowing the snakes tended to form groups, showing that aggregative drive occurs even under these circumstances. Thus we see that under high moisture levels the discs are not essential for cover. No alternative situations to high moisture levels were provided so a plausible explanation for the occurrence of exposed snakes as well as burrowing snakes is not available.

Studies on terrarium-confined *Diadophis* by Clark (1968) showed that the snakes would burrow. They selected, in fact, a soil more moist than a supposedly more fossorial species, *Carphophis amoenus*. Clark noted, however, that the more moist soil tended to clump, and facilitated penetration by *Diadophis*. Clark's substrates were sand and clay loam mixtures; we had no soil clumping problem with our sand substrate.

In another trial we tried "seeding" certain discs with marked snakes to determine whether sexual attraction occurred or if snakes simply went to a disc that had been seeded. This trial was run in September, at which time sexual drive probably was minimal. On the first two days of the pickups, before the seeding began, we found that

TABLE 13

Dispersal of ringneck snakes in an arena containing dry sand, 10 twelve-inch discs, 9 male and one female snakes. Maintained at 73 ± 2° C. Relative humidity 73% first day, thereafter 55–60%. Snakes released from center daily except where otherwise noted. Sand under discs smoothed at time of daily pickup. September.

Days after release	Disc										
	1	2	3	4	5	6	7	8	9	10	open
1	0	0	3♂ ♀	0	0	0	0	3	0	0	3
2	0	0	5♂ ♀	0	0	0	0	0	0	1	3
	Only males released from center; female placed under disc 6.										
3	0	0	0	0	0	3	0	0	0	0	6♂; ♀*
	Only males released from center; female placed under disc 1.										
4	6♂ ♀	0	0	0	0	0	0	0	0	0	3
	Only males released from center; female placed under disc 4. Males not released until day 6.										
8	0	0	0	7♂ ♀	0	0	0	0	0	0	2
9	No records taken; only 8 males released from center, along with the female. One male placed under disc 5.										
10	0	0	0	3	2	0	0	0	♀	2	2
	Released 8 males from center, placed one male under disc 2 and the female under disc 7.										
11	0	1	0	0	0	0	1♀♂	0	0	2	5

* Only one male near ♀

males aggregated with the female (Table 13). Subsequent observations after the seeding began showed no consistent patterns, regardless of whether the disc was seeded with a male or female, or both were employed (though under separate discs). Aggregations seen on days 4 and 8, involving the female, could have been sexual or could have been reflections of the tendency to come to a regularly used shelter. However, no one disc ever became popular in this experiment. On day 9 the female was released from the center with several males, and a single male was "seeded" under disc 5. By day 10 one male had joined the "seed" male under disc 5, but the female was isolated. Day 3 results also show her essentially isolated. Whether the same results might be obtained during the spring breeding season remains for subsequent experimentation.

DISCUSSION

The formation of aggregations presumably confers some benefit to ringneck snakes. The advantages might include ease of finding sexual partners, reduction of exposed body surface, with reduced moisture loss and perhaps moderation of temperature change due to weather changes, and perhaps sensual satisfaction. Sensual satisfaction actually includes a host of taxes which are more likely the mechanisms responsible for initiating aggregation rather than a result of the grouping. Clausen (1937) showed reduced oxygen consumption in aggregated *Storeria dekayi* but the advantages of this are not clear. Reduced O_2 consumption could reflect lowered metabolism, hence lower energy requirements. Certainly if the snakes were crowded under a stone or buried in the ground, O_2 would be limited. However, the animals seemingly are not forced to aggregate in nature to conserve O_2 since numerous cover stones are available.

From our experiments some factors can be discounted as the primary cause of aggregative behavior. For example, in our experiments no need for oxygen was evident because in most situations the snakes had ample cover of equal quality available but not utilized. In addition, extremely skewed sex ratios occurred in our field collections (six males to one female) suggesting that sex drive may play a fundamental role in aggregation. In our experiments sexual drive was ruled out as an advantage of aggregation

to ringneck snakes because it occurred among males in the absence of females. Henry Fitch (personal communication) confirms this sex ratio from his field studies in northeastern Kansas. He has observed that there may be a slight increase in the relative abundance of females in the summer, however the number of female snakes found then is far too low to indicate an actual sex ratio of 1:1. In future collecting, a summary of actual sex ratios for each aggregation found in the field would be instructive. Tentative observations in the field (April 1968) indicate that many groups of five aggregated adult snakes are wholly male and a group of 10 was 9 male and one female. The lack of females in many of the aggregations tends to further confirm our interpretation that sexual attraction is not a factor in aggregation. It should be noted here that sex ratios in the populations of various races of *Diadophis punctatus* reported by Blanchard (1942) range from 0.7:1 male to female to 3:1 (our interpolation). The extremes were based on small samples (under 17 animals); larger samples generally ran 1:1 to 2.4:1 (north-central Kansas) and 1.1:1 (northeastern Kansas).

A possible basis for aggregative drive is moisture conservation. Noble and Clausen (1936), Carpenter (1952), and others have observed that snakes tend to gather when humidities are low, possibly congregating in those places offering adequate or partial shelter from dehydration. Noble and Clausen also found that *Storeria dekayi* selected relatively high humidities when offered a choice and formed aggregations more readily under drier conditions. Bogert and Cowles (1947) have shown that the resistance to desiccation of reptiles may be correlated with habitats occupied. We have limited evidence that ringnecks become more gregarious when pre-moistened arenas begin to dry, but also have noted that aggregations form even when snakes are provided with drinking water and when ample soil moisture and high humidities prevail in the arenas.

Increased temperature can also produce higher metabolic rates and therefore increased water loss. Noble and Clausen (*op. cit.*) found that increased temperatures were accompanied by increased breathing rates and more moisture loss, and that under the elevated temperature conditions aggregations were more likely to form.

The possibility that reduced oxygen consumption might be advantageous should be mentioned again here. The use of more oxygen can be an indication of elevated metabolic rates, hence more loss of metabolic water. When Noble and Clausen did their studies it was believed that reptile integuments were essentially impermeable. The recent finding by Bentley and Schmidt-Nielsen (1966) that substantial loss of moisture may occur through the integument points up a need for careful analysis of moisture loss in relation to environmental conditions. Integumentary *vs.* respiratory loss notwithstanding, total moisture loss still remains the significant criterion.

Fitch (1956) reported numerous body temperature records for ringneck snakes found in the field. The most favored temperature seemed to be around 27-29° C, several degrees higher than our laboratory arenas. A laboratory temperature gradient response study by Clark (1968) closely agrees with Fitch's values. Fitch's records appear to be daytime readings (hour not stated) and body temperatures were generally 6-7° higher than optimum air temperatures. The values were not correlated. Since the other environmental variables were not quantified we cannot at this time know if temperature plays the more prominent role in stimulating aggregative drive, but aggregation seems to characterize ringnecks in the field whether the day be warm or cool. Seibert and Hagen (1947) found that *Thamnophis radix* and *Opheodrys vernalis* selected cover on an availability basis, but in hot weather they would avoid metal and go under cover that offered more effective insulation.

The observed aggregational phenomena in our arena were most pronounced during the daylight hours; tracks on the substrate and the different locations at which marked individuals were noted prove that wandering was prevalent at night. In nature nocturnal movements permit activity at times when the humidity is highest. However, in spring, when snakes are at the surface nocturnal temperatures tend to be rather low for efficient snake activity. In our laboratory neither temperature nor humidity changed noticeably during the night, only the absence

of negative phototaxis was a conferred advantage.

The aggregative behavior exhibited has been identified as an intrinsic drive since the animals not only selected each other's company but also tolerated considerable population pressure (up to 24 snakes under a single disc one foot in diameter). The strength of the drive is emphasized by the formation of groups during the first day after release. In addition, snakes consistently seemed to follow each other or the trails left on the substrate.

A more dispersed distribution is illustrated by the results given in Table 11. This experiment presented the greatest population density of any experiment (6.7 snakes/disc compared to a maximum of 4 snakes/disc in other experiments). We cannot therefore dismiss the possibility of crowding as a modifying factor in aggregation.

The aggregative denning behavior of large snakes obviously insures adequate winter shelter and facilitates mating after the spring emergence. Rising temperatures as the season progresses are accompanied by departure from the den. This is adaptive because increased temperatures mean higher metabolic needs, and necessitates more food than is ordinarily available in the vicinity of dens. Large snakes do not as a rule "clump" at the den site, usually they are separated while exposed to the sun.

The aggregation of ringnecks occurs during the springtime at the same time that large snakes are still at the den. However, the ringnecks do not disperse appreciably to receive warmth. The paucity of surface activity records prevents us from knowing if ringnecks disperse during the warmer parts of the year. Thorough explanation of distributional phenomena will not be possible until adequate data on responses to environmental variables and quantification of the physiological requirements of ringnecks are available.

Regardless of what stimuli foster or hasten aggregation of ringneck snakes, and the advantages of such aggregations, our experiments have demonstrated that these snakes show a definite preference for substrates that have been traversed and occupied by other ringnecks. Ringneck snakes have shown an ability to locate other ringneck snakes, apparently by means of visual, olfactory, or vomeronasal sensing. These snakes can apparently follow trails on the substrate and recognize soil that has regularly harbored other ringnecks. The ability of ringnecks to detect each other probably is an inherited trait, not unlike the chemical cue perception for food organisms reported for newborn snakes by Burghardt (1967). Noble and Clausen (1936) found that *Storeria dekayi* can detect areas where skin alone from other *Storeria* snakes has been rubbed over clean glass. This is a truly remarkable chemical perception since the skin of snakes is said to be non-glandular and any secretions left as a snake crawls along must be miniscule.

The habitat conditioning that results from occupancy of a substrate by ringneck snakes appears to serve purposes other than those previously assigned to various animals. In a discussion of environmental conditioning presented by Allee, *et al.* (1949), the major functions of conditioning were given as: detoxification, alteration of fecundity, production of growth promoting substances, and physical alteration rendering the substrate more porous or penetrable. In ringnecks it appears that conditioning may provide cues to other ringnecks that the conditioned site is, or was, a desirable site to occupy, at least in the field.

Our experiments attempted to nullify habitat selection but the experiments may have inadvertently been conducted within the environmental range evoking aggregative drive. Nevertheless, snakes re-released daily could have gone elsewhere to form their aggregations, and had every opportunity to use visual or other means to follow their kind. In natural settings ringnecks may use the same cover object year after year because it offers optimal microhabitat conditions. There is little reason to doubt, however, that the site may be conditioned habitat whose use is perpetuated on a continuing basis.

Little is known of the homing instinct in snakes but their ability to return year after year to a den site from great distances suggests that den sites may be conditioned habitat. Regular routes are evident (Klauber, 1956). Whether the use of such routes involves a homing instinct or the trailing phenomena as exhibited by *Storeria dekayi*

and ringneck snakes is not clear. The parallels between denning and aggregation are striking and are perhaps manifestations of comparable instinctive drives.

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A NEW TURTLE SPECIES OF THE GENUS *MACROCLEMYS* (CHELYDRIDAE) FROM THE FLORIDA PLIOCENE

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Abstract

Remains of specimens which appear to represent a new species of *Macroclemys* were excavated recently from a mid-Pliocene deposit at McGehee's Farm in Alachua County, Florida. The new species named **Macroclemys auffenbergi** was compared with *M. schmidti*, Miocene of Nebraska, and with the Pliocene-to-Recent species, *M. temmincki*.

Macroclemys schmidti is presumably the progenitor of *M. temmincki*. This presumption is based on distributional data and on the ages of the known fossils. Presumably, *M. temmincki* gave rise to *M. auffenbergi*.

The causative factor in the extinction of *M. auffenbergi* was perhaps the lowering of the water table during the mid-Pliocene.

Introduction

Pliocene remains of *Macroclemys* were excavated recently from a deposit at McGehee's Farm near Newberry, Alachua County, Florida, by staff members of the Florida State Museum. This is the first record for the genus from a Pliocene deposit in the southeastern United States although Pliocene representatives have been recorded by Zangerl (1945) and Hibbard (1963) from South Dakota and Kansas, respectively.

The assemblage of material from the McGehee site was compared with Pleistocene remains held by the University of Florida (UF) and with recent specimens deposited at Tulane University (TU), at the University of Michigan Museum of Zoology (UMMZ), and in the author's personal collection (JLD). Measurements by Zangerl (op. cit.) for the Miocene species, *M. schmidti*, Chicago Natural History Museum, (CNHM, P26014) and for the South Dakota *M. temmincki* (CNHM, P15823) were compared with the fossil remains from McGehee's Farm. In addition, two skull measurements from each of these two turtles were kindly supplied by Dr. Zangerl (personal communication). Hibbard's data (op. cit.) on the shell of the Kansas Pliocene *M. temmincki*, University of Michigan Museum of Paleontology (UMMP, 47109) were compared with the McGehee material.

The Pliocene remains from Florida appear to represent an undescribed fossil species of *Macroclemys*. I propose that it be named **Macroclemys auffenbergi** in honor of Dr. Walter Auffenberg for his contributions to our knowledge of fossil and recent turtles.

Holotype: University of Florida (UF) 10992. A nearly complete specimen (Fig. 1A-C) collected by Robert Allen in December, 1963. The carapace of the holotype lacks peripherals 8-11 on the right side, costals 3, 4, 5, and 8 on the left side, and parts of costals 6, 7, and 8 on the right side. The carapace is similar to the recent species in that three supramarginals are present on the left and right sides of the carapace and because scute sulci are the same. The carapace is approximately 455 mm long, straight line measurement. The skull lacks all bones except for the two parietals, the right quadratojugal, the left squamosal, a piece of the supraoccipital and a fragment which appears to be part of the quadrate. The right side of the mandibular ramus lacks all bones except the dentary, the left ramus is entire. The rest of the holotype is entire except for caudal vertebrae and various elements of the fore and hind feet (Fig. 1A).

Paratypes: The paratypes consist of 16 humeri (UF 9224-9228, UF 13051-13061), a basal phalanx of the third finger from a fore foot (UF 13062), two basal phalanges of the third fingers from the hind feet (UF 13063, UF 13064), an incomplete carapace

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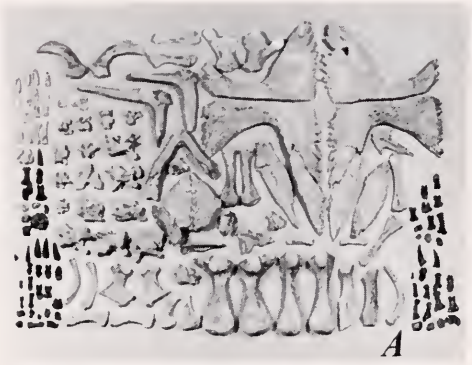

Figure 1A. Holotype remains of *M. auffenbergi*, UF10992.

Figure 1C. View of the fifth through eighth costal bones of *M. auffenbergi* (holotype, UF10992).

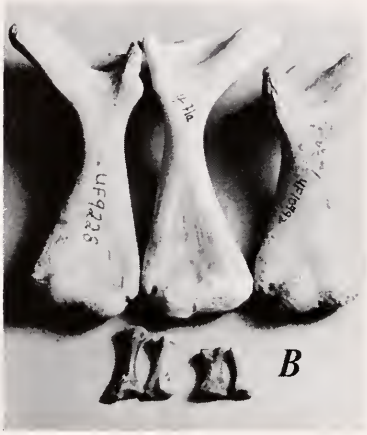

Figure 1B. A photograph showing that humeri (holotype, UF10992; paratype, UF9228) and phalanges (holotype, UF10992) of *M. auffenbergi* are wider than the same skeletal elements in *M. temmincki* (JLD 4 Florida).

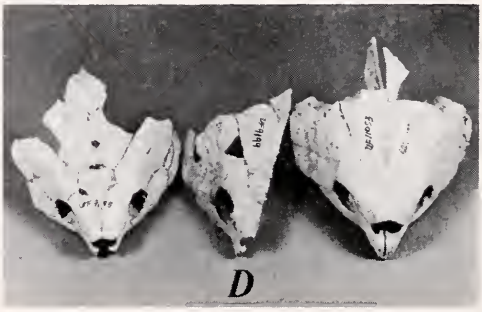

Figure 1D. Dorsal view of skulls of Paratypes UF9198-9199 and UF11053 of *M. auffenbergi.*

and plastron (UF 9242), a nearly complete skull, with an entire mandible (UF 11053), and two partial skulls (UF 9198, UF 9199; Fig. 1D).

Type locality and horizon: McGehee site; McGehee Farm, T9S, R17E, S½ of NW¼, Sec. 22, located approximately 120 yards east of State Hwy. 45 and 3 miles north of Newberry, Alachua County, Florida. The locality is a mid-Pliocene deposit of Hemphillian age (Webb, 1964).

Diagnosis and description: As the humerus of the new species increases in length (width measured at a point halfway down the length of the humerus), the width/length ratio also increases, i.e., width increases more rapidly than length. This ratio decreases for *M. temmincki,* i.e., length increases more rapidly than width. The former is positive allometry, the latter is negative. The largest ratios are found in the larger animals for *M. auffenbergi* and in the smaller animals for *M. temmincki* (Fig. 2A). There is no overlapping of ranges in width/length ratios for phalanges of digits of the fore and hind feet (Fig. 2B).

The difference among the three species in the relative length of the alveolar surface of the upper jaw is apparent in Figure 2C. However, Dr. Zangerl (personal communication) stated the following for *M. schmidti,* "the estimate of the total length: posterior

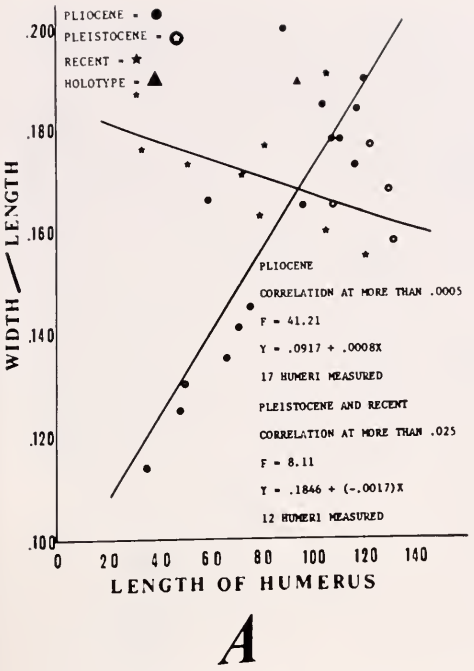

Figure 2A. Regression analyses of ratios of width/length for humeri of *M. auffenbergi* and *M. temminckii*.

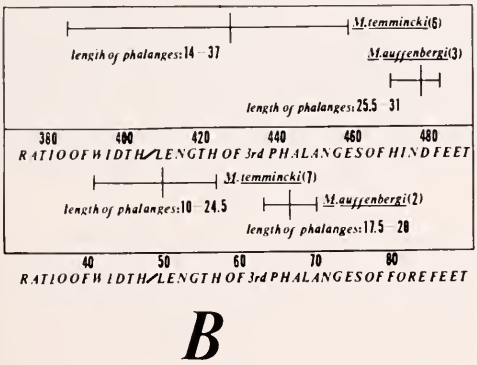

Figure 2B. Ratios of width/length for the basal phalanges of the third fingers for the fore and hind feet of *M. auffenbergi* and *M. temminckii*.

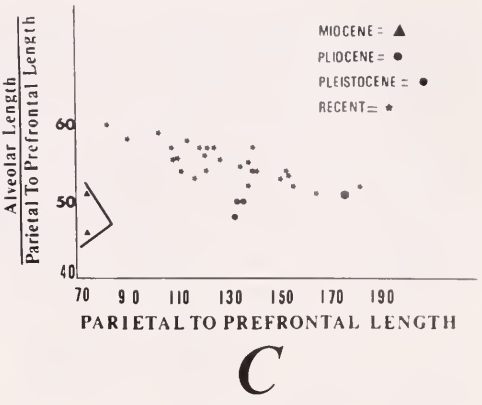

Figure 2C. Ratio of alveolar length (posterior end of alveolar shelf to anterior attachment with the premaxilla) divided by length from the posterior end of the parietal to the anterior end of the prefrontal for skulls of *M. schmidti*, *M. auffenbergi* and *M. temminckii*.

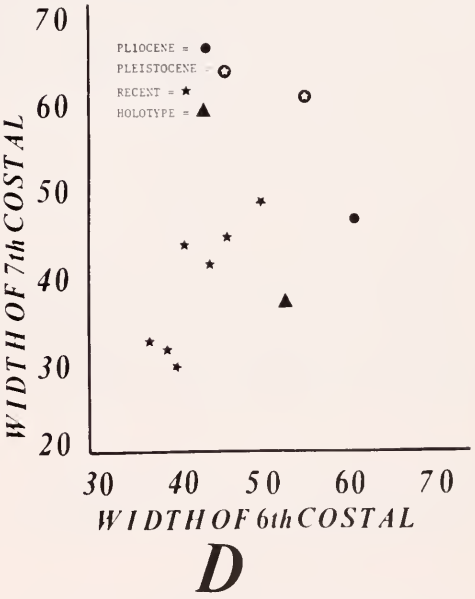

Figure 2D. Widths of the sixth costal bones of the carapace for *M. auffenbergi* and *M. temminckii*.

end of the parietal to front end of prefrontal is, of course, a wild guess based on the position of the occipital condyle." The two points for the *M. schmidti* were calculated using the two "estimated" lengths supplied by Dr. Zangerl. This datum is unavailable for the Pliocene skull from South Dakota (Zangerl, personal communication).

The new species is separable from *M. temminckii* on the basis of one character of the carapace: in the former, the sixth costal is wider than the seventh (Fig. 2D). The eighth costal bones of the holotype and paratype UF 9242 are broken. Comparison

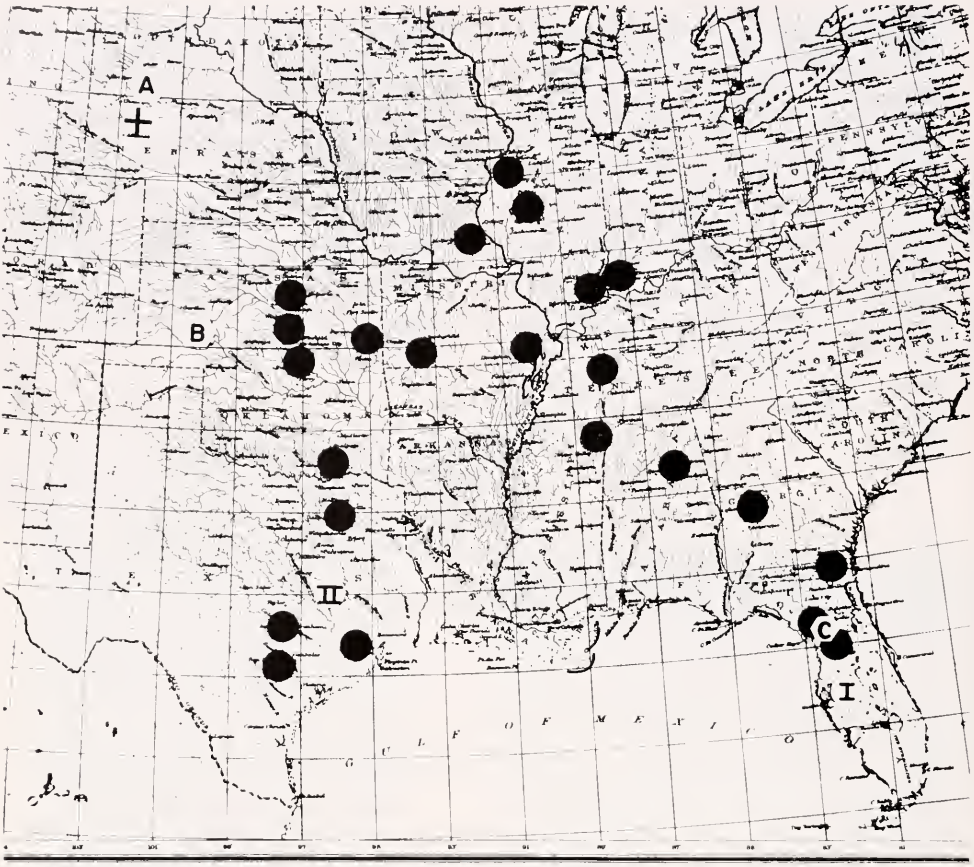

Figure 3. Former and present distribution of the genus *Macroclemys*. The + is the *M. schmidti* record from the early middle Miocene of Nebraska; A and B are records of the South Dakota (early Pliocene) and Kansas (late Pliocene) *M. temmincki*; C is the Florida (mid-Pliocene) *M. auffenbergi;* I and II are Pleistocene records for *M. temmincki;* solid dark circles are recent *M. temmincki* records.

of *M. auffenbergi* with *M. temmincki* from the upper Pliocene of Kansas (Hibbard, op. cit.) is not possible.

Discussion

Formerly the genus *Macroclemys* was more widely distributed than at present (Fig. 3). I suspect that *M. schmidti,* from the early middle Miocene of the northwestern corner of Nebraska, was the progenitor of the early Pliocene (Clarendonian)-to-Recent species, *M. temmincki.* I base this on the following facts: (1) the South Dakota deposit is close geographically to the early middle Miocene deposit in Nebraska; (2) the South Dakota deposit is early Pliocene; the Florida site (Hemphillian age) is middle Pliocene. *Macroclemys temmincki* is thus older than the new species and presumably gave rise to *M. auffenbergi.*

The Pliocene river(s) inhabited by *M. auffenbergi* was probably a "typical" river with a fauna similar to those that now populate southeastern rivers. The two new fossil species of *Chrysemys* (= *Pseudemys*) (Rose and Weaver, 1966) discovered at the McGehee deposit support this view.

It seems probable, in view of the close structural similarity between these turtles, that habitat requirements for *M. auffenbergi* were similar to those of *M. temmincki,* i.e., thoroughly aquatic, sedentary, omnivor-

ous, and necrophagous (Dobie, 1966; unpublished dissertation).

The question arises as to why *M. temmincki* has persisted, while *M. auffenbergi* has become extinct. Perhaps the extinction of the latter resulted from a lowering of the water table during a period of arid Pliocene climate. *Macroclemys temmincki* survived because its range included the Mississippi River and certain major tributaries, that persisted through this arid period.

Acknowledgments: I appreciate the review of this manuscript by Robert H. Mount of Auburn University and the loan of Pliocene and Pleistocene specimens by Walter Auffenberg of the Florida State Museum at the University of Florida, Gainesville.

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December 23, 1968

STUDIES ON FROG TRYPANOSOMIASIS
II. SEASONAL VARIATIONS IN THE PARASITEMIA LEVELS OF *TRYPANOSOMA ROTATORIUM* IN *RANA CLAMITANS* FROM LOUISIANA

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ABSTRACT

Seasonal variations in the parasitemia level of *Trypanosoma rotatorium* infections of *Rana clamitans* are described. The seasonal cycle of parasitemia is not influenced by the sex of the frog. Preliminary data also suggest that in frogs over 5.1 cm long, the age of the frog had no apparent relation to the percentage of infected frogs or the parasitemia level. Various factors, i.e., water temperature, mating cycle, changes in photoperiod, which might influence the seasonal cycle are discussed. The importance of these results in epidemiological studies of parasitic infections is also discussed.

INTRODUCTION

Numerous species of trypanosomes have been described from various species of frogs in the United States. Much of the early taxonomic work has been reviewed by Diamond (1965). He also discussed the biology of trypanosomes infecting frogs, including methods of cultivation, vectors involved in transmission, laboratory maintenance of frogs, vectors, and so forth.

Nigrelli (1945) described a morphological type of trypanosome infecting *Rana clamitans*. He identified this species as *Trypanosoma rotatorium* (Mayer, 1843). This species is the one reported in this paper. Diamond (1965) believes that *T. rotatorium* (Mayer, 1843) has not been described from frogs captured in America. He did not, however, name the species which has been regarded as *T. rotatorium* by Nigrelli (1945). Until more concrete evidence regarding the true identity of *T. rotatorium* (Mayer, 1843) of Nigrelli (1945) becomes available, we will continue to identify this trypanosome as *T. rotatorium*.

There have been few or no reports on the incidence or intensity of *T. rotatorium* infections of *R. clamitans*. The work to be reported here describes the parasitemia levels of *T. rotatorium* infections of *R. clamitans* captured near Norco, Louisiana throughout a 1½ year period.

MATERIALS AND METHODS

The frog, *Rana clamitans*, was collected throughout the year from swamps in the Goodhope oil field near Norco, Louisiana. It was maintained in glass aquaria and exposed to the normal daily fluctuations of light. Subsequent to its capture, each frog was weighed, measured from the tip of snout to vent, and if possible its sex determined from external characters. To determine parasitemia levels, a vein in the upper corner of the jaw was punctured, blood extracted with a micro Pasteur pipette, and placed on a microslide. Slides were examined under low power (125 ×) with the light microscope. Frogs were examined within 3 days of capture, almost always between the hours of 12:00 noon and 7:00 p.m. This is the period of maximum parasitemia level (Southworth, et al., 1968). Trypanosomes contained in a drop of blood covered with a 22 mm square cover slip were counted and averaged for a minimum of 30 low power fields. Only those fields which contained a relatively constant number of red blood cells were examined. In addition, a drop of blood under a 22-mm-square cover slip was systematically

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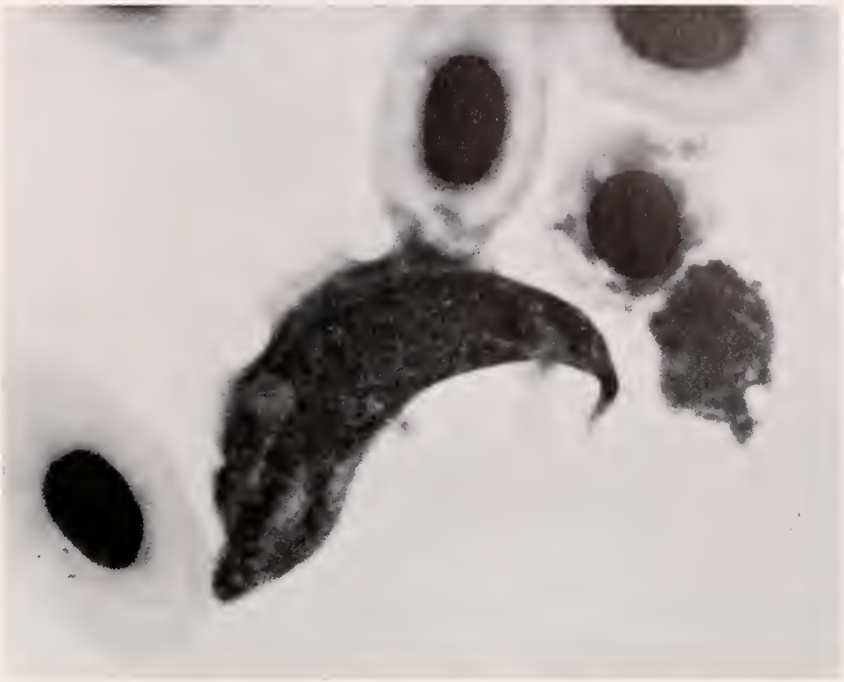

Figure 1. *Trypanosoma rotatorium* in *Rana clamitans* from Louisiana (1800×). The measurements made on trypanosomes from stained blood smears are as follows: Posterior end to kinetoplast, 4.92 μ (9); Posterior end to center of nucleus, 16.5 μ (38); Posterior end to anterior end, 46.2 μ (49); with including undulating membrane, 14.5 μ (49); No free flagellum. The numbers in parentheses are the number of measurements made.

examined from those frogs which appeared negative for trypanosomes. In one collection (30 Jan. 1967), the frogs were examined for *T. rotatorium* every 4 hours over a 24-hour period.

Trypanosoma rotatorium was differentiated from the other morphological types of trypanosomes found in the fresh blood preparations of *R. clamitans* by their characteristic size, shape, absence of a free flagellum, and type of movement. *Trypanosoma rotatorium* was the largest trypanosome observed, generally assumes a U-shape, and moves with closed end of the U leading.

For the measurement of trypanosomes, blood smears were prepared and stained with Giesma's stain. Measurements were made under oil immersion with the light microscope (1250×).

Results

In examining the blood of 486 *Rana clamitans* collected over a period of 1½ years 81 per cent were found to be infected with *Trypanosoma rotatorium* (Mayer, 1843). The measurement and morphology of this trypanosome corresponds exactly to the elongate forms of *T. rotatorium* described by Nigrelli (1945) from *Rana clamitans* collected in New York, Connecticut, New Jersey and Pennsylvania. The morphology of *Trypanosoma rotatorium* is shown in Figure 1. *Rana clamitans* was also found to be infected with at least 5 other different and discrete morphological types of trypanosomes. The incidence and intensity of infection of these other types were low, and they will not be discussed in this report.

The parasitemia levels and incidence in frogs showing the presence of circulating blood *T. rotatorium* are indicated in Tables 1 and 2 and Figure 2. The difference in the parasitemia level of frogs captured in the late summer (17 August 1966) when compared to the parasitemia level of frogs captured in the winter were highly significant (Table 2). Table 3 shows that the sex of the frog does not influence the parasitemia

Table 1
Seasonal variation in the percentage of *R. clamitans* with *T. rotatorium* in the peripheral blood.

Date Frogs Collected	Number of Frogs Collected[1]	Percentage of Frogs with *T. rotatorium* in Peripheral Blood	Water Temperature °C
2 Aug. 65	3	100	ND[2]
27 Aug. 65	10	100	26.5
30 Sept. 65	15	93	ND
27 Oct. 65	23	78	15.0
3 Nov. 65	29	76	ND
17 Nov. 65	17	59	15.0
1 Dec. 65	6	66	10.0
6 Jan. 66	23	13	15.0
24 Feb. 66	7	0	9.5
10 Mar. 66	71	66	14.0
17 Mar. 66	28	93	19.0
24 Mar. 66	16	94	15.0
1 April 66	20	100	ND
14 April 66	14	93	20.0
12 May 66	21	90	23.5
9 June 66	2	100	ND
8 July 66	17	100	28.0
1 Aug. 66	13	100	28.0
10 Aug. 66	29	97	26.5
17 Aug. 66	30	100	27.0
27 Sept. 66	36	100	24.0
7 Nov. 66	16	100	24.0
30 Jan. 67	10	0	ND
Totals	456	—	—
Average	—	81	20.0

[1] All frogs greater than 5.0 cm in length.
[2] not determined

levels. Frogs of both sexes showed approximately equal parasitemia levels throughout the year (probability $< 10\%$). Preliminary data in Table 4 suggest that the age (size) of the frog does influence the parasitemia level. Frogs 4.0 cm or less in length were generally negative for trypanosomes, whereas a higher percentage of frogs above 4.1 cm captured at the same period showed detectable circulating trypanosomes. In frogs above 5.1 cm, there was no significant increase in parasitemia level or percentage of infected frogs with increase in age (size).

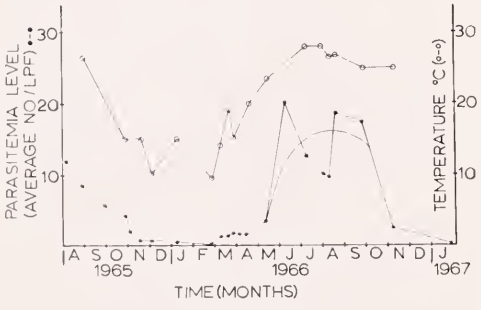

Figure 2. Seasonal variation in the blood parasitemia level of *Trypanosoma rotatorium* from *Rana clamitans*.

Discussion

It appears that the parasitemia level of *Trypanosoma rotatorium* in *Rana clamitans* varies seasonally. The parasitemia level or seasonal cycle is not influenced by the sex of the frog. Additionally in frogs over 5.1 cm long the age (size) of the frog had little apparent relation to the parasitemia level or seasonal cycle. The seasonal cycle may be correlated with the water temperature from which the frogs were captured (Figure 2). Frogs captured in the field during the end of January and February were consistently negative for circulating blood trypanosomes. These same frogs when brought into the laboratory became positive at approximately the same time that the incidence and intensity of infection increased in other frogs obtained from the field. These

Table 2
Seasonal variation in the blood parasitemia level of *T. rotatorium* from *R. clamitans*.

Date Frogs Collected	Number of Frogs Collected[1]	Average Parasitemia Level (No./LPF)	Range	Probability (%)[2]
2 Aug. 65	3	1.20 ± 0.90	0.2–2.0	NS[3]
27 Aug. 65	10	0.81 ± 0.53	0.3–2.0	> 0.1
30 Sept. 65	15	0.59 ± 0.56	0–2.0	> 0.1
27 Oct. 65	23	0.43 ± 0.58	0–2.0	> 0.1
3 Nov. 65	29	0.20 ± 0.31	0–1.5	> 0.1
17 Nov. 65	17	0.06 ± 0.05	0–0.1	> 0.1
1 Dec. 65	6	0.07 ± 0.05	0–0.1	> 0.1
6 Jan. 66	23	0.01 ± 0.04	0–0.1	> 0.1
24 Feb. 66	7	0	0	> 0.1
10 Mar. 66	71	0.13 ± 0.28	0–2.0	> 0.1
17 Mar. 66	28	0.12 ± 0.08	0–0.5	> 0.1
24 Mar. 66	16	0.21 ± 0.18	0–0.6	> 0.1
1 April 66	20	0.19 ± 0.12	0.1–0.5	> 0.1
14 April 66	14	0.16 ± 0.16	0–0.6	> 0.1
12 May 66	21	0.33 ± 0.48	0–2.0	> 0.1
9 June 66	2	2.00 ± 2.70	0.1–3.9	NS
8 July 66	17	1.24 ± 1.94	0.1–7.8	NS
1 Aug. 66	13	1.10 ± 0.62	0.1–2.1	> 5
10 Aug. 66	29	0.96 ± 0.71	0–2.3	> 2
17 Aug. 66	30	1.75 ± 1.00	0.1–3.7	—
27 Sept. 66	36	1.77 ± 1.21	0.2–4.5	NS
7 Nov. 66	16	0.24 ± 0.16	0.1–0.6	> 0.1
30 Jan. 67	10	0	0	> 0.1

[1] All frogs greater than 5.0 cm in length.
[2] Based on student's "T" test. The parasitemia levels of frogs captured on 17 August 1966 were compared to the parasitemia levels of frogs captured at other times of the year.
[3] Not statistically significant ($P = < 10\%$)

results are preliminary and require further verification, however, they do indicate (1) that negative frogs probably are not truly negative but harbor low undetectable numbers of trypanosomes; and (2) that temperature is not solely responsible for the variable parasitemia levels, since the laboratory temperature was relatively constant and warmer than field conditions. The frog seasonal mating cycle and/or seasonal changes in photoperiod may play a role in controlling intensities of infection. Both of these possibilities are currently under investigation.

There have been few epidemiological studies on trypanosome infections of frogs. Diamond (1965) reported that 27% of *Rana pipiens* collected from Anoka and Ramsey County, Minnesota were infected with *Trypanosome pipientis*. Diamond also reported a 38.5% infection of *R. pipiens* from Anoka County, Minnesota collected on the 22 July 1949. These percentages are considerably lower than those reported here, and suggest that the incidence of infection and intensities of infection by frog trypanosomes may vary according to the geographical area and time of the year in which the frogs are examined. The presence of a 24-hour cycle influencing varied parasitemia levels of *T. rotatorium* in *R. clamitans* has been described (Southworth, *et al.*, 1968), and suggests that the time of day must also be considered in any analysis. In other words, to compare any two host populations of one species in similar climatic areas for the incidence and intensity of infection it would be necessary to examine all hosts at comparable daily and seasonal times.

Acknowledgments

The authors would like to thank Dr. Franklin Sogandares-Bernal who greatly encouraged us in this work.

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TABLE 3
Sex and seasonal variation in blood parasitemia level of *T. rotatorium*.

Date Frogs Collected	Male Frogs			Female Frogs		
	Number of Frogs Collected[1]	Percentage of Frogs with *T. rotatorium* in Peripheral blood	Average Parasitemia Level (No./LPF)	Number of Frogs Collected	Percentage of Frogs with *T. rotatorium* in Peripheral blood	Average Parasitemia Level (No./LPF)
6 Jan. 66	6	0	0	17	18	0.02 ± 0.04
10 Mar. 66	20	70	0.17 ± 0.43	51	65	0.12 ± 0.15
17 Mar. 66	11	91	0.15 ± 0.13	17	94	0.11 ± 0.05
24 Mar. 66	4	75	0.13 ± 0.13	12	100	0.23 ± 0.19
1 April 66	3	100	0.17 ± 0.12	17	100	0.19 ± 0.12
14 April 66	5	100	0.16 ± 0.14	9	89	0.17 ± 0.17
12 May 66	4	75	0.13 ± 0.13	17	94	0.38 ± 0.49
8 Jnly 66	8	100	1.83 ± 2.71	9	100	0.76 ± 0.66
1 Aug. 66	6	100	0.90 ± 0.40	7	100	1.28 ± 0.75
10 Aug. 66	11	100	0.92 ± 0.62	18	94	0.98 ± 0.77
17 Aug. 66	17	100	1.62 ± 1.04	13	100	1.95 ± 0.96
27 Sept. 66	15	100	1.65 ± 1.15	21	100	1.83 ± 1.25
7 Nov. 66	2	100	0.20 ± 0.14	14	100	0.24 ± 0.18
Totals	112	—	—	222	—	—
Average	—	86	—	—	84	—

[1] All frogs greater than 5.0 cm in length.

TABLE 4
Body length and blood parasitemia level of *T. rotatorium* and *R. clamitans*.

Date Frogs Collected	Body Length[1]														
	4.0 cm or less			4.1–5.0 cm			5.1–6.0 cm			6.1–7.0 cm			7.1–8.7 cm		
	No[2]	%[3]	$\bar{x}$[4]	No	%	$\bar{x}$	No	%	$\bar{x}$	No	%	$\bar{x}$	No	%	$\bar{x}$
10 Mar. 66	9	11	0.01 ± 0.04	13	31	0.04 ± 0.07	47	62	0.11 ± 0.15	22	77	0.20 ± 0.20	2	50	0.13 ± 0.17
24 Mar. 66	2	0	0	1	0	0	10	90	0.13 ± 0.09	5	100	0.30 ± 0.24	1	100	0.5
1 April 66	1	0	0	1	100	0.1	8	100	0.18 ± 0.14	12	100	0.09 ± 0.12	0	0	0
12 May 66	1	0	0	9	78	0.46 ± 0.6	7	86	0.17 ± 0.11	11	91	0.27 ± 0.33	3	100	0.82 ± 1.02
17 Aug. 66	0	0	0	2	100	2.5 ± 0.86	18	100	1.63 ± 1.02	12	100	1.98 ± 1.03	0	0	0
27 Sept. 66	0	0	0	11	100	1.45 ± 1.02	28	100	1.82 ± 1.17	7	100	1.86 ± 1.45	1	100	1.2
Totals	13	—	–	37	—	—	118	—	—	72	—	—	7	—	—
Average	—	7.8	–	—	68	—	—	83	—	—	92	—	–	86	—

[1] Body length measured from tip of snout to vent.
[2] Number of frogs collected.
[3] Percentage of frogs with *T. rotatorium* in Peripheral Blood.
[4] Average parasitemia level (No./LPF).

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December 23, 1968

STUDIES ON AMERICAN PARAGONIMIASIS VI. ANTIBODY RESPONSE IN THREE DOMESTIC CATS INFECTED WITH *PARAGONIMUS KELLICOTTI.**

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Abstract

Sera obtained approximately every 10 days from three domestic cats exposed to varied numbers of metacercariae of *Paragonimus kellicotti* were examined for complement fixing and precipitating antibody for a period of 150 days after exposure. The responses obtained are shown and discussed.

Introduction

Serological tests have been developed for the clinical diagnosis of human paragonimiasis infections (Sadun *et al.,* 1959), but there have been few attempts to determine the type of antibody response throughout the course of human or animal infections. Sadun *et al.* (1959) have studied the complement fixing antibody response in cats experimentally infected with *Paragonimus westermani.* These authors first detected complement fixing antibody 30 days following the inoculation of a single dose of metacercariae and remained positive for at least 130 days. In their work, however, there was no description of the antibody response between 30 and 130 days, or of possible fluctuations in antibody titers.

Several recent attempts have been made to characterize the antigens from adult *Paragonimus westermani* and *P. kellicotti* obtained from naturally and experimentally infected cats (Yogore, Jr., Lewert, and Madraso, 1965; and Seed, Sogandares, and Mills, 1966). These reports are in close agreement that adult worms have a minimum of 5 precipitating antigens as shown by agar-diffusion techniques. As in the previous work on complement fixing antibody, however, no attempt was made to follow the type of antibody response throughout the entire infection. It is considered conceivable that failure to determine the antibody response throughout an infection might possibly produce misleading results. It is also believed possible that the quantity and specificity of precipitating antibody molecules might vary throughout the infection.

This work describes our observation of sera obtained from infected cats approximately every 10 days throughout the course of 150-day infections.

Materials and Methods

Three domestic cats (5 to 10 lbs body wgt.) were exposed by pipetting, *per os,* varied numbers of metacercariae of *P. kellicotti.* The cats were partially sedated by an intraperitoneal injection (1 m. 4% solution 5 lbs body wgt.) of thiamylal sodium (Surital®, Parke, Davis and Co.) and bled by heart puncture. The cats were bled prior to exposure to *P. kellicotti* and at approximately 10 day intervals until they were killed. Sera were stored at −30°C until needed. The adult worms were harvested from cats, their uteri removed, washed several times in normal saline, and then stored at −30°C until needed. The cats were necropsied for helminthic infections of the intestine. These cats were maintained in

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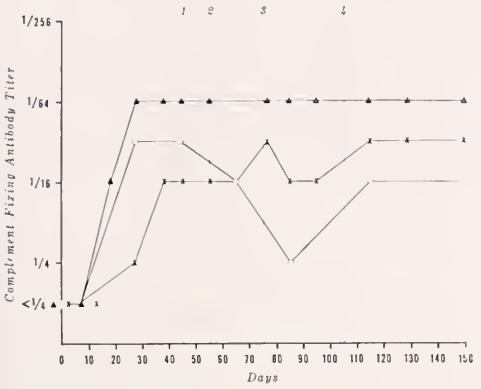

Figure 1. The time course of complement fixing antibody in cats infected with *Paragonimus kellicotti*. 1. A chronic cough first observed in cats CFS-20 and 21. 2. Eggs of *P. kellicotti* first observed in fecal samples from cat CFS-21. 3. Eggs of *P. kellicotti* first observed in fecal samples from cat CFS-20. 4. CFS-18 fed a second metacercaria. X cat 18; ○ cat 20; ▲ cat 21.

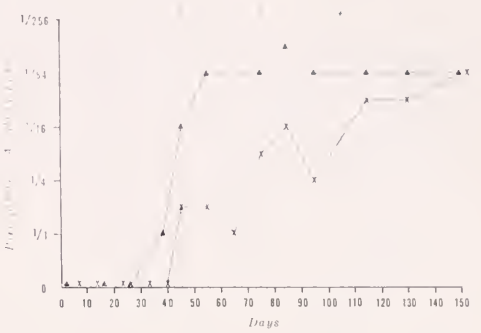

Figure 2. The time course of precipitating antibody in cats infected with *Paragonimus kellicotti*. See Figure 1 for explanation of numbers 1 to 4. X cat 18; ▲ cat 21.

relatively good health throughout the infection as shown by continuous weight gains.

Stool samples were obtained weekly from the infected cats, and were examined by Ritchie's (1948) ether-formalin concentration techniques for eggs of *P. kellicotti*.

Paragonimus extracts were prepared as previously described (Seed, Sogandares, and Mills, 1966). Approximately 20 adult worms were suspended in 8 ml of distilled water and homogenized with the aid of a hand glass homogenizer. The homogenate was then centrifuged at 12,000 × G for 10 min in a refrigerated International Centrifuge. The sediment was discarded and the supernatant was used as the antigen. All antigens were stored at −30°C until needed.

Protein was assayed by the method of Lowry *et al.* (1951). All antigen suspensions were made to contain 4.0 to 5.0 mgs protein per ml. In a previous publication (Seed, Sogandares, and Mills, 1966) we stated that our suspensions contained 0.4 to 0.45 mg protein per ml. This was an error in the placement of a decimal point in the manuscript and text and should have read 4.0 to 4.5 mg protein per ml.

Serological tests:

1) Agar diffusion tests were performed as described by Ouchterlony (1958). The agar used consisted of a 0.5% distilled water solution of Oxoid Ionagar, No. 2 to which was added glycine (0.5%) and merthiolate (0.1%) (Thimerosal®, Eli Lilly and Co.). The agar was then adjusted to pH 7.0 with 0.5M NaOH. 20 ml of agar were poured into each petri plate and wells were made with a No. 5 cork borer. The distance between the centers of adjacent wells was 14.0 mm. The wells were filled with approximately 0.1 ml of antigen or antibody. The plates were kept at room temperature and the results recorded at 24, 48 and 72 hours.

Precipitating antibody was titrated in agar diffusion plates using twofold dilutions. The end-point was taken as the last dilution at which a visible precipitin line was found.

2) The complement fixation test was performed by a modification of the Kolmer method for syphilis (Kolmer, Spaulding, and Robinson, 1951). A ¼ dilution of antiserum was the lowest dilution tested, due to the anti-complementary activity of some cat antisera. Glycerinated anti-sheep hemolysin, lyophilized guinea pig complement, and 2% sheep red blood cells, were all obtained from the Colorado Serum Company, Denver.

Results

The presence of both complement fixing and precipitating antibody was detected in sera of infected cats, confirming previous results. A minimum of 6 precipitating bands was found in agar diffusion plates indicating the presence of at least six antigens in extracts of adult *P. kellicotti*. This is one

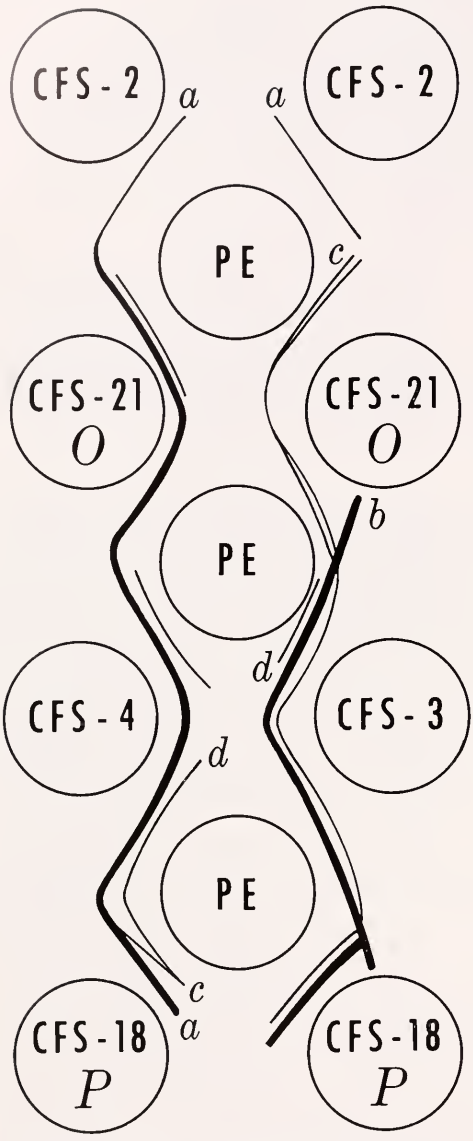

Figure 3. Gel diffusion patterns produced by infected cat serum and *Paragonimus kellicotti* extracts. The *Paragonimus* extract (PE) contained 4.0 mg protein per well; 0.1 ml antigen or antibody was used per well. Sera CFS-2, 3 and 4 have been described previously (Seed Sogandares and Mills, 1966). The plates were read at 24 and 48 hrs and a final reading was made at 72 hrs.

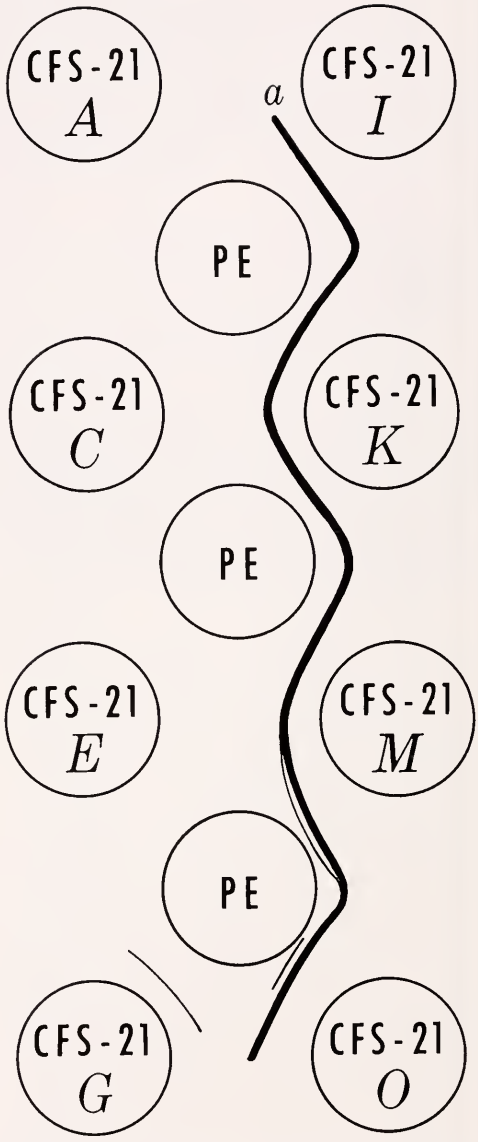

Figure 4. Gel diffusion patterns produced by sera, from an infected cat, taken at varied time intervals and tested against *Paragonimus kellicotti* extracts. The methods and materials were identical to that described for Figure 4. The time in days at which serum was obtained: CFS-21A (0), CFS-21C (8), CFS-21E (27), CFS-21G (43), CFS-21I (65), CFS-21K (85), CFS-21M (115), and CFS-21O (150).

Table 1
Data on infected cats from which sera were obtained.[1]

Cat number	Number of metacercariae fed	*Paragonimus* recovered at autopsy	Other helminth infections[4]	Patency of *P. kellicotti*	Maximum precipitation titer	Maximum complement fixation titer
CFS-18	2[2]	2[3]	unidentified nematode	none	1/64	1/32
CFS-20	42	36[5]	*T. cati* *D. caninum*	patent	–	1/32
CFS-21	21	21[5]	*T. cati* *D. caninum*	patent	1/128	1/64

[1] All cats were infected for 150 days.
[2] Fed one metacercaria 8 March 1966, and another 21 June 1966.
[3] Unencysted migrating preadults recovered at autopsy.
[4] Determined by fecal examinations and by autopsy.
[5] Adults only recovered.

more antigen than reported previously (Seed, Sogandares, and Mills, 1966). These results are in agreement with those of Tada (1967) who observed a maximum of six precipitin bands in serum from a rat infected with *Paragonimus miyazakii*. The detection of an additional band is presumably due to the greater length of time allowed for pattern development prior to the final recording of our results (48 versus 72 hours). As previously shown, the precipitating antibody response appears to vary in infected cats. Serum CFS-3 contained at least one unique antibody specificity not found in CFS-18 and 21 (Figure 3). Serum CFS-20 contained no detectable precipitating antibody, although the largest number of adult worms was recovered from this cat (Table 1). Figure 4 suggests that although the intensity and position of the precipitating bands in agar diffusion plates changes during the early stages of the infection, the same bands are found throughout the infection. This suggests, assuming our methods are sensitive enough, that the cat does not experience different antigenic stimuli from the adult worms during the course of the infection.

Figures 1 and 2 show the precipitating and complement fixing antibody titers throughout the course of a *Paragonimus* infection of cats. Both the precipitating and complement fixing antibody curves are similar in that once antibody is detected there is a sharp rise in titer and then a plateau is attained. The antibody titers are then maintained at a high level throughout the course of the infection. One obvious difference between the precipitating and complement fixing antibody curves is that complement fixing antibody is detected considerably earlier in the infection. Cat (CFS-20) contained no detectable precipitating antibody by the agar diffusion test but significant complement fixing antibody titers were found.

Figures 1 and 2 also show that there is no obvious correlation between the rise and titer of complement fixing and precipitating antibody, and egg production or clinical symptoms (chronic cough). Cat (CFS-18), which never showed the presence of eggs in its stool, contained definite precipitating and complement fixing antibody. The complement fixing antibody was detected considerably earlier than the passage of eggs or a noticeable cough.

Conclusions

It is apparent from these data that both complement fixing and precipitating antibodies arise relatively early (17 and 37 days) during *P. kellicotti* infections of the cat. The antibody titer then reaches a plateau and remains high throughout the infection. This is to be expected since the adult worms would presumably release antigen(s) throughout the entire infection. Our results are similar to those reported by Sadun *et al.* (1959) for *P. westermani* infections in the cat using the complement fixation test, and also So (1959) who investigated the precipitating antibody response in rabbits and dogs infected with *P. ohirai*.

Tada (1967), however, reported a decrease in the number of precipitating anti-

bodies in sera from rats with long-term *P. miyazakii* infections. He suggested that the cyst surrounding the adult worms might impede the passage of excretory substances and, therefore, account for the reduced antibody response.

It was of interest that cat (CFS-20) which had the highest worm burden failed to show detectable precipitating antibody. One additional cat, (CFS-2), which was reported upon previously and had the next highest worm burden (30 adults recovered), also showed an unexpectedly low precipitating antibody titer. Numerous suggestions can be made to explain the low level or absence of detectable precipitating antibody in heavily infected cats. However, the most interesting possibilities to us are the phenomena of immune paralysis or the absorption and removal of circulating antibody by the large number of adult worms and their antigens. Both explanations might readily account for the data obtained, and are amenable to further experimentation.

Sogandares (1966) indicated that *P. kellicotti* infections became patent only in cats whose lung cysts contained two or more worms. Cat CFS-18 had been fed a single metacercaria, followed by a second 106 days later; the infection never became patent even 44 days after feeding of the second metacercaria, and two unencysted migrating preadults were recovered after 150 days. Patency usually results 30 to 44 days, past exposure to metacercariae, when two or more worms locate in a single lung cyst. In view of Sogandares' (1966) findings and in our recovery of two unencysted immature worms from cat CFS-18, in whose sera both complement fixing and precipitating antibodies could be demonstrated, it is strongly suggested that some complement fixing and precipitating antibodies may be produced in the absence of eggs passing through the host lung tissues. Since the sera from cat CFS-18 had essentially the same precipitin patterns in agar diffusion plates as sera from other cats containing adult worms, our findings also suggest that preadults produce antigens in common with the adult worms. This is in agreement with the work of Tada (1967) who found precipitating antibody to adult worms in infected rats prior to the encystment of the adults in the lung.

The detection of complement fixing antibody considerably earlier than the detection of precipitating antibody, as well as the detection of complement fixing antibody in cat (CFS-20) which failed to produce significant levels of precipitating antibody, might be due to the greater sensitivity of the complement fixation test. The possibility should also be considered that the complement fixing antigen(s) and the precipitating antigens are not identical. The early rise in complement fixing antibody might prove the complement fixation test valuable as a possible diagnostic tool especially early in infection prior to patency. Sadun *et al.* (1959) previously suggested a similar use of the complement fixation test based on their observations of *P. westermani* infections in cats.

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PLANOPHILA TERRESTRIS, A NEW GREEN ALGA FROM TENNESSEE SOIL

ROBERT D. GROOVER AND SISTER ADRIAN MARIE HOFSTETTER, O.P.

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TULANE STUDIES IN ZOOLOGY AND BOTANY

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PLANOPHILA TERRESTRIS, A NEW GREEN ALGA FROM TENNESSEE SOIL

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ABSTRACT

A new chlorosphaeracean alga, *Planophila* **terrestris,** is described from Tennessee soil.

Hofstetter (1968) has reported on the distribution and identification of previously described soil algae from twelve areas in Shelby County, Tennessee. During this investigation an organism tentatively identified as a new chlorosphaeracean alga was isolated into unialgal culture. Because of the first author's special interest in the Chlorosphaeraceae (*sensu* Herndon, 1958), the organism was studied jointly during the summer of 1967.

Unialgal cultures were maintained in Pringsheim's soil-water medium (Starr, 1964). Axenic cultures were obtained using the techniques of Brown and Bischoff (1962). The axenic cultures were maintained and studied in Bold's Basal Medium (BBM) with and without 1.5 per cent agar (Brown and Bold, 1964). The cultures were grown in a culture room under standard conditions, namely 300 ft c light (cool-white fluorescent) on a 12-hr light, 12-hr dark cycle at 22 C.

Morphological observations were made routinely on cultures varying in age from one day to three months. Acetocarmine, Haidenhain's haematoxylin, aqueous iodine (I_2KI), India Ink, and Sudan IV were used to elucidate certain aspects of the cellular morphology. The photomicrographs were made with a Bausch and Lomb microscope with a 35-mm Zeiss-Winkel camera attachment.

OBSERVATIONS

Planophila **terrestris** sp. nov.

(Figs. 1-16)

Cellulae vegetativae sphericae, 6-15.2 μ diam ad paululum ellipsoideas, 14-18 μ × 18-26 μ; membrana cellulae tenuis levisque, senescens paululum spissescens, chloroplastus parietalis, in cellulis maturis perforatus; unatres pyrenoides omni in cellular; cellulae per crescentiam uninucleatae; vacuolae contractiles in cellulis vegetativis observatae; fasciculi cellularum duo-quattuor-cellulares, plerumque due-dimensionales, per divisiones cellularum vegetativarum successivas effecti; cellulae vetustae numerosas guttulas olei minutas habentes; cellulae brunneo-aurantiae; culturae senescentes colonias *Hormotilopsis*-formes effectae.

Reproductio per dissociationem fasciculorum cellularum aut per zoosporas quadriflagellatas aut per aplanosporas; zoosporae elongatae, per bipartitionem iteratam effectae, 3-6 μ lat. × 7-16 μ long., sine membrana, nucleum anteriorem, stigma anterius lineare, duas vacuolas contractiles anteriores,

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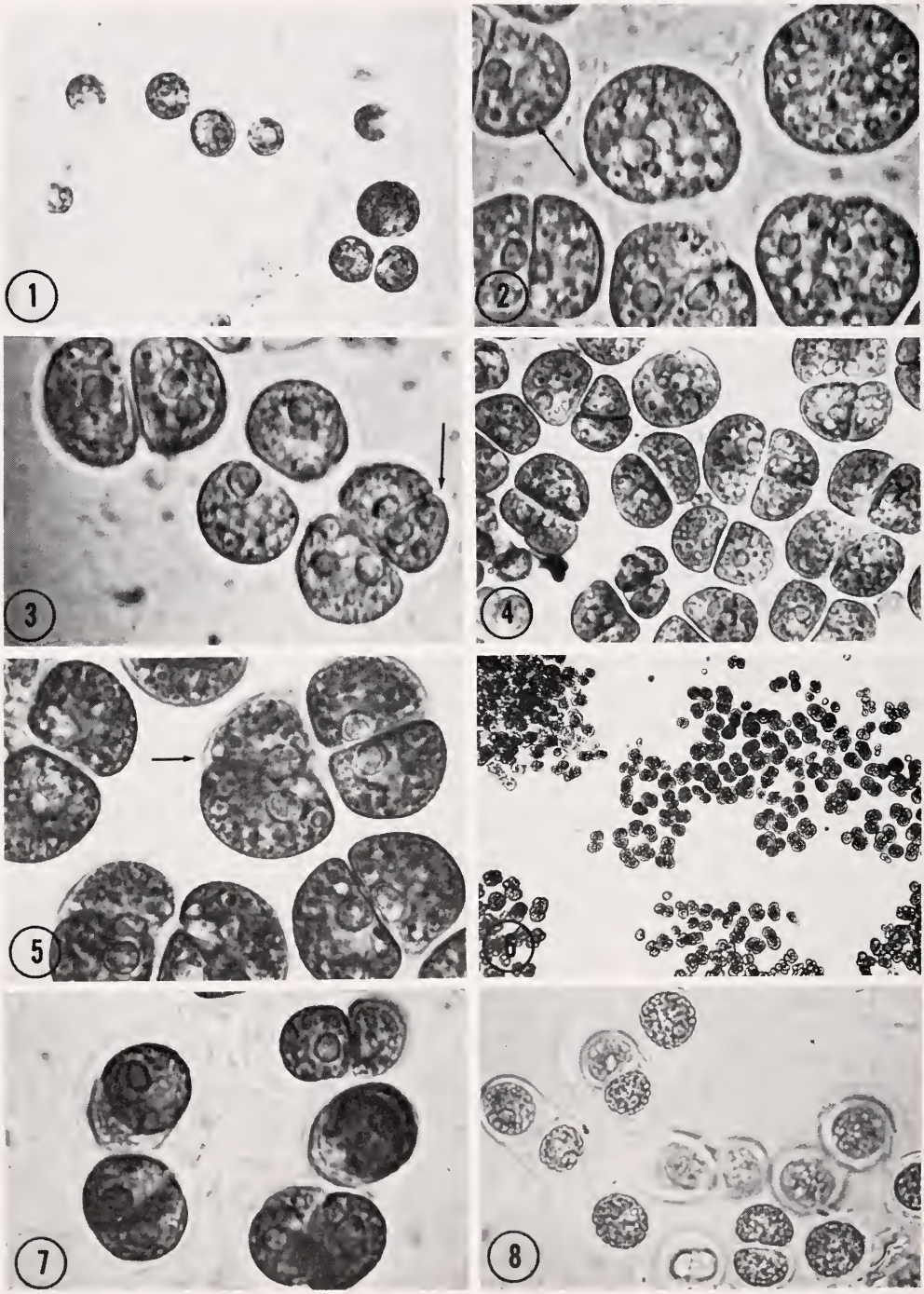


Figures 1-8. *Planophila terrestris.*
Figures 1-6. Cells from actively growing cultures on 3N BBM agar.
Figure 1. Young cells; note parietal plastid, one pyrenoid per cell, and variation in cell size. × 600.

pyrenoidem posteriorem aut interdum mediam, et plastidem parietalem habentes; zoosporogenesis per examinantem directam interdum effecta.

Reproductio sexualis non observata.

Massa plantalis in agaro 3N BBM dicto culta aetate 2 et 4 hebdomadum sine microscopio observata sicca, magnificatione 14 × observata aspera (minute glomerulata), consistencia butyracea, in culturis veteribus in periodo immobili brunneo-aurantia facta.

Origo: Plantae e solo horti culto in loco Memphis, Shelby County, Tennessee dicto. m. Nov., 1966 lectae; numerus culturae R-81.

In actively growing cultures, young vegetative cells, recently derived from zoospores, are spherical to slightly ellipsoidal (Fig. 1). Such cells, generally 6-11 μ in diameter, attain a diameter of 15.2 μ in cultures 4 days old. The chloroplast in young cells is typically parietal and covers most of the cell surface (Fig. 1). The plastid soon becomes perforate (Fig. 2) and contains from one to three pyrenoids (Figs. 1-5); the cells are uninucleate. Young cells contain numerous colorless lipid droplets (Fig. 2). One or two contractile vacuoles have been observed in vegetative cells. The walls of cells in actively growing cultures are thin and smooth (Figs. 1-5) but become slightly thickened with age (Figs. 8 and 9). Solitary cells which fail to divide vegetatively or to undergo zoosporogenesis may be slightly ellipsoidal, 14-18 × 18-26 μ.

Vegetative cell division (*sensu* Herndon, 1958) is characteristic of log-phase cultures. During cytokinesis a partition is laid down across the center of the parent cell, dividing it into two daughter cells which remain in close association with the parent cell wall. The daughter cells, in turn, may undergo vegetative cell division. The direction of each division is usually perpendicular to the preceding division giving two-dimensional, four-cell packets (Figs. 2-6). Not infrequently, three-dimensional, cuboidal, eight-celled packets are produced. The packets may dissociate either partially or entirely to form diads or solitary cells.

In stationary-phase cultures, a unilateral deposition of wall materials results in the formation of branching *Hormotilopsis*-like colonies (Figs. 7 and 8). Cells from such cultures are brownish-orange due to the presence of colored oil droplets.

Asexual reproduction is by zoospores and aplanospores (Figs. 10-15). Both solitary cells and those in packets may produce zoospores by successive bipartition of the maternal protoplast. Usually four (Fig. 10), sometimes two or eight, zoospores are produced by each parent cell. Zoospores are released through a pore formed by a gelatinization of the zoosporangial wall. Occasionally the protoplast of a single cell behaves as a single zoospore (Fig. 11). In such cases the remains of the parent wall are often visible in the culture medium (Fig. 11). The zoospores, elongate in shape, are 3-6 μ wide and 7-16 μ long. Each has a parietal plastid, an anterior nucleus, an anterior linear stigma, two contractile vacuoles, and a posterior, sometimes medial, pyrenoid. The zoospores have four flagella of equal length (Fig. 12). They lack a wall (*Protosiphon*-type, Starr, 1955) and become spherical at quiescence. The period of motility is several hours. The eyespot is persistent and may be observed for several hours after the zoospore has become nonmotile. The zoospores may be rapidly motile or exhibit slow, amoeboid movements.

Aplanospores (Figs. 14 and 15) are formed in the same manner as zoospores and are morphologically similar. They develop a wall prior to their release by a gelatinization and rupture of the aplanosporangial wall.

Macroscopically the plant mass of *Planophila terrestris* on 3N BBM[1] agar is dry; at 14× it is rough and glomerulate (Fig.

[1] BBM with 3× the usual amount of $NaNO_3$.

←

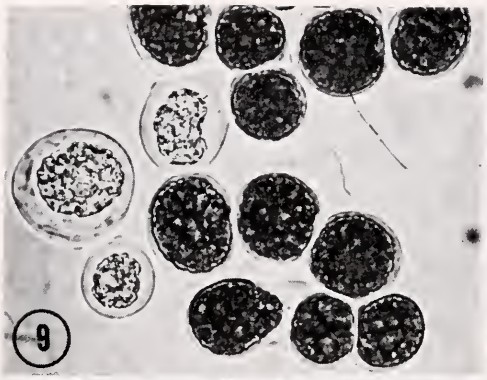
Figure 2. Cells showing perforate condition of chloroplast. The numerous droplets (arrow) in the cells are Sudan-IV-positive and probably lipid. × 1500.

Figures 3, 4. Typical packets. Note cells with more than one pyrenoid and dividing cell (arrow). Figure 3, × 1250; Figure 4, × 800.

Figure 5. Cells illustrating contiguity of the parent wall around packet (arrow). × 1200.

Figure 6. Cells arranged in typical packets. × 100.

Figures 7, 8. Cells from stationary-phase cultures on 3N BBM agar; note branched *Hormotilopsis*-like organization. Figure 7, × 700; Figure 8, × 500.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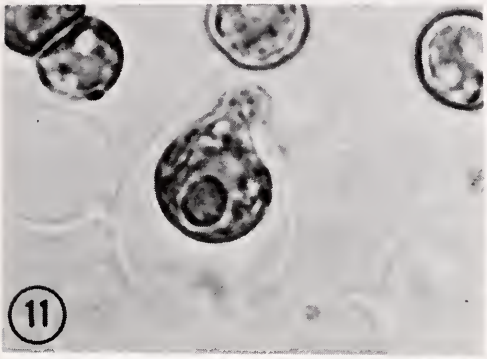
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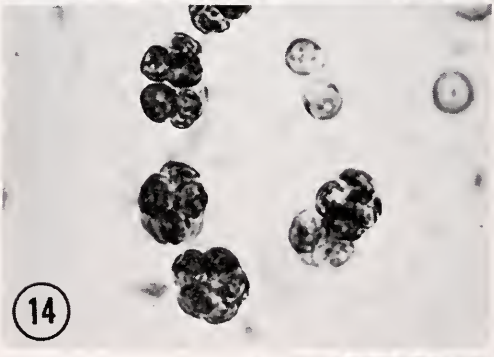
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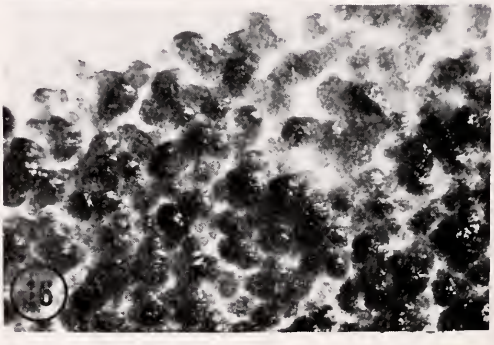
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16); its consistency on agar is butyrous. Actively growing cultures are green but change with age through various shades to a brownish-orange.

Discussion

Only a small number of green, nonfilamentous algae reproducing by quadriflagellate zoospores have been described. In two genera, *Fernandinella* Chodat (1922) and *Tetraciella* Pascher and Petrova (1930), the cells are typically pyriform. Fott and Kalina (1965) consider the two genera to be synonymous. In the tetrasporalean alga *Hormotilopsis* Trainor and Bold (1953), persistent packets are absent. The genus *Planophila* Gerneck (1907) is characterized by spherical cells which divide vegetatively in two directions to form flat (i.e., two-dimensional), two-eight-celled packets. In determining the taxonomic position of the organism herein described, the descriptions and illustrations of the four above-named genera and their species were studied in the original references and also in several other sources: Wille (1911), Arce and Bold (1958), Reisigl (1964), Fott and Kalina (1965), and Bourrelly (1966).

The morphological attributes of this organism, though not in complete agreement with the generic descriptions of any of the four genera, are sufficiently close to *Planophila* to warrant its classification in this genus. The isolate described here differs distinctly from the species of this genus treated by Gerneck (1907) and Reisigl (1964) and accordingly, it is described as a new taxon.

The majority of species of *Planophila* have their cells in a flat, biseriate packet. The packets of *P. terrestris* are frequently cuboidal but this characteristic is not of sufficient importance to remove it from the genus. The cuboidal packets of cells, the presence of a *Hormotilopsis*-like stage, and the much greater length of the zoospores distinguish *P. terrestris* from the other three species.

The species of *Planophila* may be distinguished as follows:

1. Stationary-phase cultures forming *Hormotilopsis*-like stages; zoospores elongate, up to 16 μ in length ..... *P. terrestris* sp. nov.
1. *Hormotilopsis*-like stage not reported; zoospores less than 10 μ long 2
   2. Zoospores without an eyespot ..... *P. asymmetrica* (Gerneck) Wille (1911)
   2. Zoospores with an eyespot 3
3. Solitary cells 6-8 μ in diameter; pyrenoids two; zoospores 6.5 μ long, 4 μ wide ..... *P. bipyrenoidosa* Reisigl (1964)
3. Solitary cells 5-15 μ (-22) μ in diameter; pyrenoid one; zoospores almost spherical, 6 μ in diameter ..... *P. laetevirens* Gerneck (1907)

A culture of *Planophila terrestris* has been deposited in the Culture Collection of Algae, Indiana University, Bloomington, Indiana and an herbarium specimen in the Field Museum of Natural History, Chicago, Illinois.

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Figures 9-16. *Planophila terrestris*.

Figure 9. Cells from stationary-phase cultures on 3N BBM agar; note thickened cell walls. × 725.

Figures 10-15. Cells from actively growing cultures on 3N BBM agar.

Figure 10. Zoospores prior to release, four per sporangium (arrow). × 1200.

Figure 11. Direct swarming; note liberation of entire protoplast as a single zoospore and persistence of parental walls. × 2000.

Figure 12. Single zoospore. Note quadriflagellate condition and position of pyrenoid. Phase-contrast. × 1500.

Figure 13. Zoospore. Note parietal plastid, position of pyrenoid, and position of eyespot (arrow). × 1800.

Figures 14, 15. Aplanosporangia; eight aplanospores per parent cell in Figure 14 and four per cell in Figure 15. Figure 14, × 300; Figure 15, × 1000.

Figure 16. Surface view of plant mass; 2-week-old culture on 3N BBM agar. × 16.

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LIFE CYCLES OF *CARNEOPHALLUS CHOANOPHALLUS* N. SP. AND *C. BASODACTYLOPHALLUS* N. SP. (TREMATODA: MICROPHALLIDAE)[1]

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Abstract

The life histories of two new microphallid trematodes *Carneophallus* **choanophallus** and *Carneophallus* **basodactylophallus**, from South Louisiana are reported. The natural hosts for *C. choanophallus* are: the raccoon, *Procyon lotor* (L) and the black rat, *Rattus rattus* (L) [definitive hosts], the snail, *Lyrodes parvula* Guilding, 1928 (unspined form) [first intermediate host], and the shrimp, *Macrobrachium ohione* Smith, 1874 and *Palaemonetes pugio* Holthuis, 1949 [second intermediate hosts]; for *C. basodactylophallus*: the raccoon [definitive host], the snail *Lyrodes parvula* Guilding, 1828 (spined form) [first intermediate host] and the blue crab, *Callinectes sapidus* Rathbun, 1896 [second intermediate host]. The cercariae of the two species differ primarily in stylet length and experimentally were not capable of cross-infecting the crustacean hosts.

Cercarial penetration, development and growth of the metacercariae of *C. choanophallus* are described. A 15-month geographical and ecological study of infected *M. ohione* in the Mississippi River is presented.

Introduction

Freshwater shrimp, *Macrobrachium ohione* Smith, 1874, from the shallow water of the west bank of the Mississippi River at Ama, Louisiana were collected in July, 1966. The musculature of the abdomen and the cephalothorax of these shrimp was infected with metacercariae of an unidentified microphallid trematode. Further study showed that the metacercariae were larvae of a new species of *Carneophallus* Cable and Kuns, 1951. An intensive search for the other stages of the life-cycle and an ecological study of the infected shrimp led to the finding of high incidences of densely infected *M. ohione* in several areas near the mouth of the Mississippi River. It was subsequently found that black rats, *Rattus rattus* (L), from Fort Jackson, Louisiana and raccoons, *Procyon lotor* (L), from Pass a Loutre, Louisiana were naturally infected with adults of the new species. Further examination of the small animal runways in the marshes and ponds at Pass a Loutre, Louisiana led to the discovery of the snails, *Lyrodes parvula* Guilding, 1896 (unspined form) which harbor the cercariae. The grass shrimp, *Palaemonetes pugio* Holthuis, 1949, was also found to harbor metacercariae in endemic areas.

During studies on the life history of the microphallid from *M. ohione*, metacercariae of another new, very closely related, species of *Carneophallus* were discovered in the blue crab, *Callinectes sapidus* Rathbun, 1896. Adults of this form were also found in raccoons, and the snail, *Lyrodes parvula* Guilding, 1896 (spined form) was found to harbor cercariae which infect the blue crab.

Materials and Methods

Mississippi River shrimp, *Macrobrachium ohione* Smith, 1874 and the brackish water grass shrimp, *Palaemonetes pugio* Holthuis, 1949, were used in studies and experiments with *Carneophallus choanophallus*, while the blue crab, *Callinectes sapidus* Rathbun, 1896, was used for those dealing with *Carneophallus basodactylophallus*. These crustaceans were collected from various natural habitats with baited traps, dip nets and by dredge-

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trawling from a small boat. *M. ohione* collected for studies of shrimp size, incidence, and intensity of infection, were collected with ¼-inch-mesh wire traps (baited) attached to the river bank with 10- to 25-foot-long lines at the ruins of the old Sellers Plantation House at Ama, Louisiana. The shrimp were transported to the laboratory for observation and study in aerated minnow buckets. Measurements of total length of the shrimp are in millimeters from the end of the rostrum to the tip of the telson. The total length measurements were grouped into classes of 5-mm increments. Metacercariae were counted by examination of the transparent shrimp body under low power of a dissecting microscope. Shrimp and crabs were maintained in the laboratory in aerated aquaria or in individual containers. They were fed dried dog food (Austin's Baked Dog Food, Sunshine Biscuits, Inc., Long Island, New York) every other day followed by a change of water several hours after each feeding.

Naturally and laboratory infected shrimp and crabs were used to infect suspected definitive hosts. Metacercariae for infection experiments were counted by placing small pieces of cyst-containing tissue under the dissecting microscope. Laboratory definitive hosts were exposed by feeding metacercariae in small pieces of shrimp or crab tissue.

Excystment of metacercariae was done in 0.75 per cent saline with sharp needles; however, the worms usually excysted spontaneously when allowed to stand in saline for several hours or overnight at room temperature.

Natural definitive hosts were collected in the endemic areas by live-trapping along the bank of the river and by shooting by day and by night from a small boat equipped with a spotlight. In the laboratory, small mammals were killed by a sharp blow to the back of the head, larger mammals were killed by etherization. Within 30 minutes of killing or shooting, the mammal's small intestine was taken out and the adult trematodes were removed by slitting and scraping the gut into containers of 0.75 per cent saline. For larger animals, the small intestine was usually cut into 4-inch lengths before slitting. Examination was done in petri dishes under the low power of a dissecting microscope.

Spined and unspined snails of the species *Lyrodes parvula,* which carried the two species of *Carneophallus* cercariae, were collected with the aid of a large tea strainer from fresh to brackish water marshes and ponds where small animal trails could be seen in the marsh grass (*Spartina* spp.), alligator weed (*Alternanthera* spp.) and the water weed (*Cabomba* spp.). Snails were taken to the laboratory and those observed to be shedding cercariae were isolated. Snails used for incidence studies were crushed on glass plates in a drop of 0.75 per cent saline and observed under a dissecting microscope for cercariae. All snails were maintained in the laboratory in aquaria containing vegetation and water with the salinity adjusted to match that of the collecting area. Since snails were collected from areas near the mouth of the Mississippi and Pearl Rivers, the salinity was found to vary from time to time. The snails were induced to shed cercariae by placing them in small containers of water adjusted to the proper salinity and subjecting them to a slight increase in temperature under an ordinary reading light bulb for several hours.

Shrimp or crabs were preadapted to water of the proper salinity and then exposed to cercariae. Injecting the cercariae into the gill chambers was also effective. If shrimp maintained in the laboratory for 15 days or more showed no metacercariae in their transparent bodies under the low power of the dissecting microscope, they were considered uninfected and were used for infection experiments. Staged studies of metacercarial development in *M. ohione* were done in an incubator maintained at 27 C. Crabs from certain localities (Willswood and Osgood Ponds 12 miles west of New Orleans on U.S. Highway 90) were found to be very lightly infected. These crabs were maintained in the laboratory for three weeks before being exposed to cercariae. Laboratory infections with thin cyst walls were then easily distinguished from natural infections.

Eggs were teased from the uteri of adult worms and their development was followed in containers of water which was changed twice weekly.

Both fixed and living material were used to study all stages of the life-cycles in the present study. Neutral red and nile-blue sulfate vital stains were used. Whole mounts

TABLE 1.
Geographical distribution, incidence and density of *Macrobrachium ohione* infected with *Carneophallus choanophallus* metacercariae from four Louisiana Rivers.

Location	Mile[1]	Number of Shrimp	Number of Collections	Incidence (Per cent)	Average Density per Shrimp
MISSISSIPPI RIVER					
Greenville, Miss.	540	47	1	23.3	0.32
Vicksburg, Miss.	435	10	1	30.0	0.60
New Roads, La.	260	93	2	26.8	0.85
Plaquemine, La.	210	202	2	22.7	0.69
Wallace, La.	135	198	4	20.2	0.38
Bonnet Carre Spillway, La.	125	308	3	22.0	0.66
Ama, La.	115	9994	120	22.4	0.84
Empire, La.	30	13	1	46.1	2.69
Fort Jackson, La.	20	661	9	67.6	3.65
Baptiste Collette Pass, La.	10	246	4	64.4	5.28
Pass a Loutre, La.	−5	484	8	71.0	4.23
ATCHAFALAYA RIVER					
Morgan City to Charenton, La.		125	2	0.8	0.008
RED RIVER					
Highway 107 at Vick, La.		25	1	0.0	0.0
WEST PEARL RIVER					
Highway 90 to Pearl River, La.		0	3	0.0	0.0

[1] Mile numbers indicate the distances above and below (−) Head of Passes, La. at the mouth of the Mississippi River (see *Flood Control and Navigation Maps of the Mississippi River, Cairo, Illinois to the Gulf of Mexico*, 34th Ed. (1966) prepared by the U. S. Army Corps of Engineers. 68 maps, 12 charts, 43 sheets).

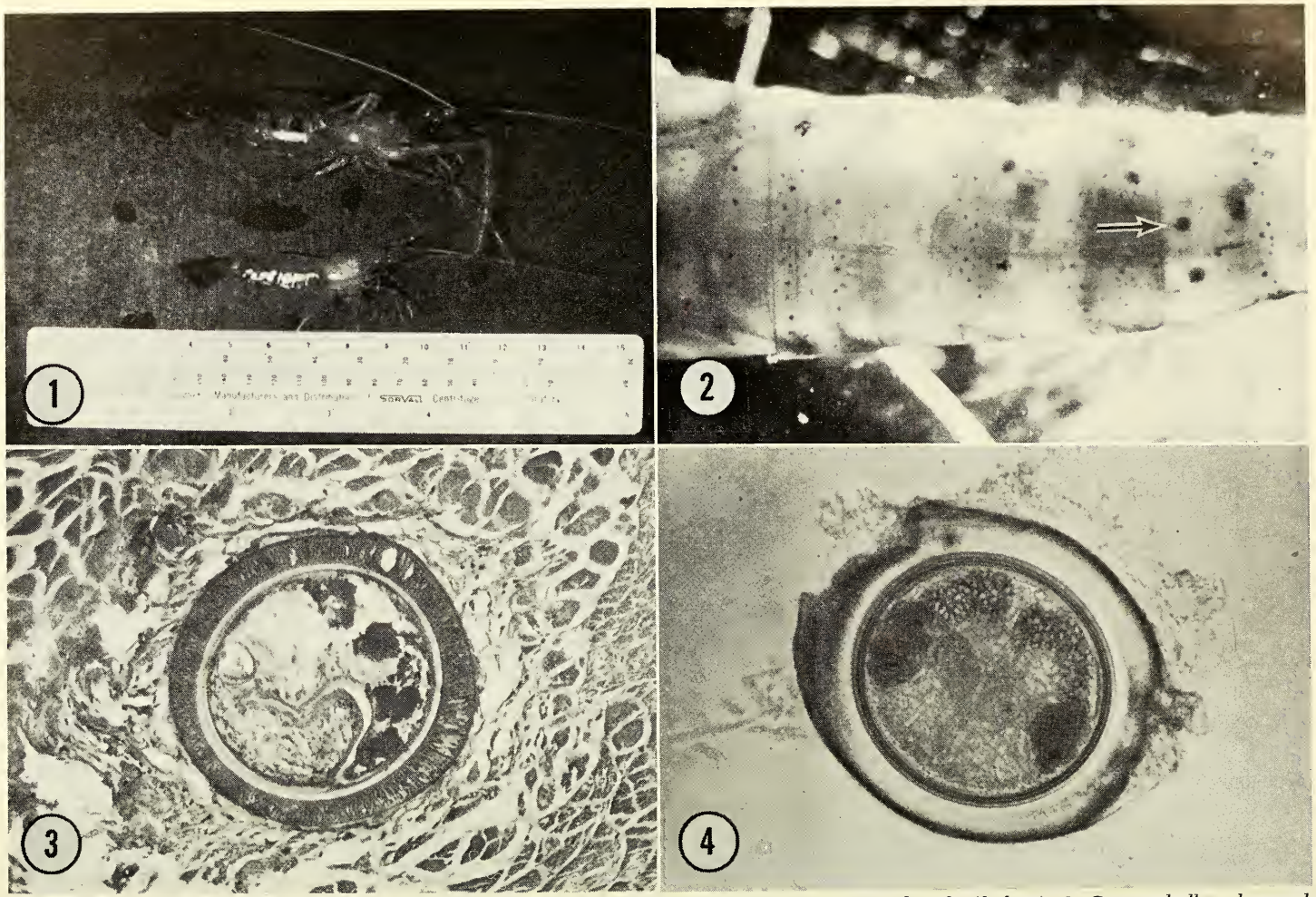
were fixed in alcohol-formalin-acetic acid fixative and stained in Van Cleave's (1953) combination hematoxylin, then mounted in Permount® (Fisher Scientific Company). Adult specimens used for growth studies were killed in hot water before being fixed to assure a standard state of body contraction. Drawings were made free-hand and with the aid of a microprojector. Measurements are in millimeters unless otherwise specified.

Carneophallus from *Macrobrachium ohione* and *Palaemonetes pugio*

The Life-Cycle

In the fall of 1966, Mississippi River shrimp, *Macrobrachium ohione* Smith, 1874, were collected from the shallow water of the west bank of the Mississippi River at Ama, Louisiana. Twenty to 30 per cent of these shrimp had from 1 to 60 microphallid metacercariae in their transparent body musculature (Figs. 1 and 2). Excysted metacercariae revealed a well differentiated preadult trematode which demonstrated all the characteristics of the genus *Carneophallus* Cable and Kuns, 1951. Metacercariae were fed to laboratory rats and mice and ovigerous adults obtained from the intestine 5 to 25 days post-exposure as well as excysted metacercariae were used to identify this trematode as a new species of *Carneophallus*.

An intensive search for the other phases of the life-cycle was made in the Ama, Louisiana region. All snails and suspected definitive hosts taken from this study area were examined for microphallid cercariae and adults with negative results. A geographical and ecological survey of the infected shrimp (Table 1) finally pointed the way to marsh and pond areas between the distributaries at the mouth of the Mississippi River near the Louisiana State Fish and Wild-Life Camp at Pass a Loutre, Louisiana, where the incidence and density of shrimp infection was considerably elevated. Examination of numerous animals observed to be feeding on shrimp revealed that the raccoon, *Procyon lotor* (L), and the black rat, *Rattus rattus* (L), were naturally in-



Figures 1-4. 1. *Macrobrachium ohione* (Mississippi River shrimp) typical female (above) and male (below). 2. *Carneophallus choanophallus* metacercaria (arrow) in abdominal musculature of *M. ohione*. 3. Paraffin section of mature *C. choanophallus* metacercaria in *M. ohione* demonstrating the layers of the cyst wall. 4. Fifty-day-old laboratory infection (room temperature) of *C. choanophallus* metacercaria dissected from *M. ohione* muscle.

fected with species of *Carneophallus,* includ- the new species.

Raccoons and rats were observed to make runways in the alligator weed (*Alternanthera* spp.), marsh grass (*Spartina* spp.) and the water weed (*Cabomba* spp.) in the Pass a Loutre area. With the aid of a large tea strainer, amnicolid snails, the spined and unspined forms of *Lyrodes parvula,* were collected from runways and brought back to the laboratory where they were observed to be infected with microphallid cercariae. Although the cercariae shed from the two snail types appeared to be identical at first, only those from the unspined form of *L. parvula* were capable of infecting shrimp. Careful examination with vital stains later demonstrated morphological differences in the cercariae. Usually the unspined form of *L. parvula* was found on vegetation in the open ponds where *Cabomba* predominates, whereas the spined form of *L. parvula* was found along the edges of the ponds and marshes in the dense vegetation. Young shrimp, *M. ohione,* and *Palaemonetes pugio* in these ponds were heavily infected with the new metacercariae.

While field work was under way, laboratory experimentation was conducted to determine which of several animal types could serve as possible definitive hosts. The results of the survey were as follows: All mammals including white mice (ICR strain), white rats (Sprague-Dawley strain), cats, a raccoon, guinea pigs, meadow mice (*Microtus montanus*) and cotton rats (*Sigmodon hispidus*), which were fed metacercariae yielded good numbers of ovigerous adult worms 12 hr to 25 days post-exposure. Of eight chicks and four Pekin ducklings fed large numbers of metacercariae, only one chick upon necropsy yielded two nonovigerous worms 24 hr post-exposure. The others sacrificed 24 to 96 hr post-exposure yielded no worms. Frogs, *Rana pipiens* and *R. grylio,* maintained at room temperature yielded nonovigerous worms upon necropsy 12 to 96 hr post-exposure. Turtles, *Graptemys* spp., did not become infected. All mammals fed metacercariae from *M. ohione* and *P. pugio* were susceptible to infections producing ovigerous specimens. The frogs, turtles and birds were either not susceptible or unable to produce mature ovigerous infections under normal conditions.

These studies demonstrated that the raccoon and the black rat are natural definitive hosts for *Carneophallus* metacercariae from *M. ohione* and *P. pugio;* however, any shrimp-eating mammal could probably serve as well. The first intermediate host is a snail, the unspined form of *Lyrodes parvula,* which shed cercariae demonstrated to produce experimental infections in shrimp, *M. ohione* and *P. pugio,* identical to those found in nature. This life-cycle of the *Carneophallus* metacercariae from *M. ohione* and *P. pugio* is illustrated in Figure 5 A. The description of this new species follows:

Description of the Stages of the Life History of Carneophallus **choanophallus** n. sp.

The Adult (Figures 6-8)

SPECIFIC DIAGNOSIS: (based on 80 hot water-killed unflattened specimens from *Procyon lotor, Rattus rattus, Rattus norvegicus albinus* (Sprague-Dawley strain), *Mus musculus albinus* (ICR strain) and *Felis domesticus.*) Microphallidae: *Carneophallus.* Body pyriform, sometimes with posterior notch, 0.355 to 0.520 long by 0.200 to 0.340 wide. Forebody 0.155 to 0.325 long. Integument of anterior 1/2 of body spined. Oral sucker subterminal, 0.045 to 0.057 long by 0.050 to 0.062 wide. Prepharynx very short. Pharynx 0.025 long by 0.025 wide. Esophagus extending from pharynx to approximately anterior 1/3 body, 0.065 to 0.137 long. Ceca two, extending posteriorly and obliquely from cecal bifurcation at posterior end of esophagus, 0.037 to 0.160 long. Acetabulum equatorial, mesial, 0.042 to 0.062 long by 0.042 to 0.062 wide. Sucker ratio 1:0.89 to 1.03.

Genital pore sinistral to acetabulum, followed by genital atrium diameter approximately equal to acetabulum. Testes two, side by side in posterior 1/3 body, edges smooth, oval in outline: right testis 0.011 to 0.051 long by 0.027 to 0.079 wide; left testis 0.056 to 0.118 long by 0.037 to 0.071 wide. Vasa deferentia joining anterior to acetabulum, connecting with right posterior margin of seminal vesicle. Seminal vesicle club-shaped, preacetabular, transverse to longitudinal axis of body, tapered to form slender sperm duct surrounded by prostate gland cells at distal tip. Sperm duct connecting with fleshy intra-atrial collared geni-

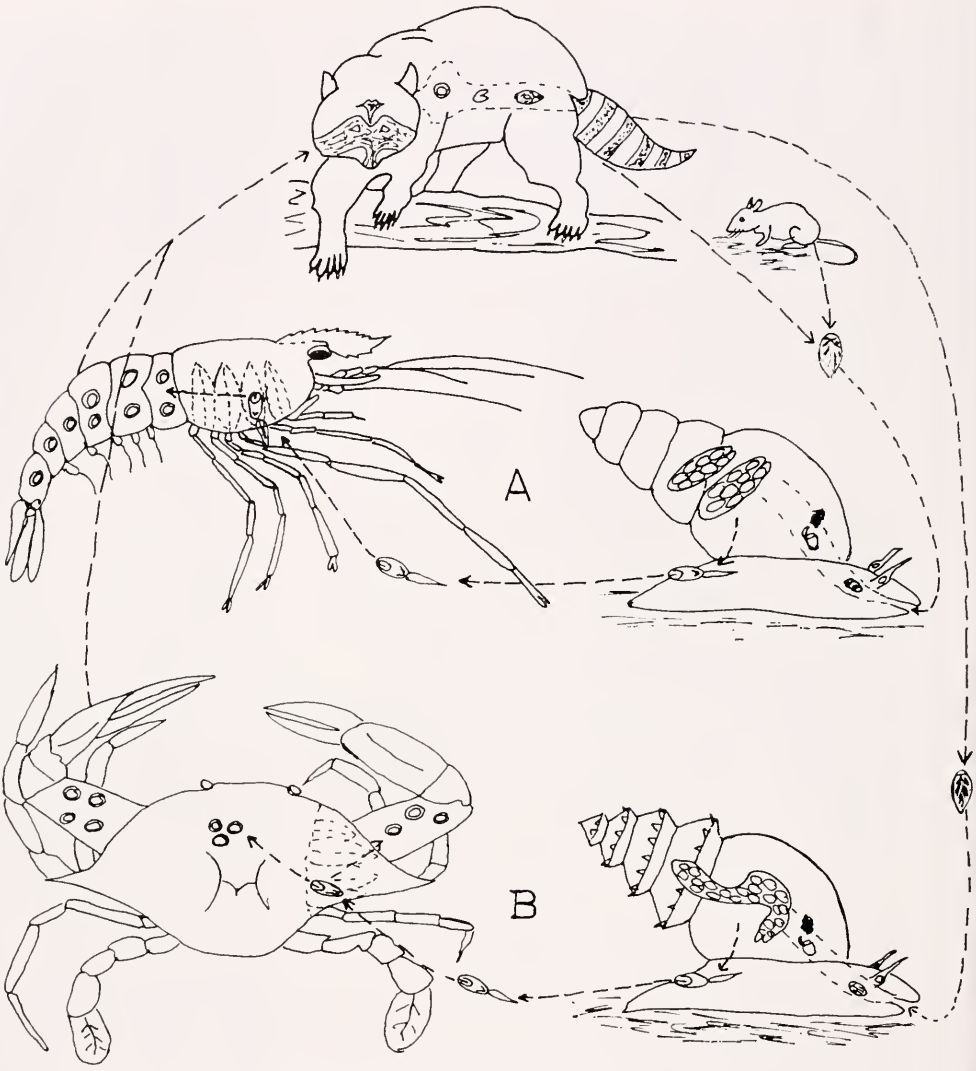


Figure 5. Diagrammatic representation of the life-cycles of (A) *Carneophallus choanophallus* and (B) *Carneophallus basodactylophallus.*

tal papilla, 0.045 to 0.062 long by 0.040 to 0.062 wide. Ovary between seminal vesicle and dextral testis; oval to oblong in outline, edges lightly lobed, 0.030 to 0.077 long by 0.037 to 0.087 wide. Uterus descending from mesial intertesticular Mehlis' gland to fill posterior body, ascending along body wall to posterior tip of dextral cecum, descending to posterior body, ascending along body wall to posterior tip of sinistral cecum, connecting with slightly enlarged metraterm surrounded by gland cells which in turn connects with genital atrium. Vitellaria composed of 6 to 11 coarse follicles on each side of body, extending from posterior ends of ceca to posterior 1/8 of body. Uterine eggs operculate, 16 to 17 microns long by 10 to 12 microns wide. Excretory vesicle V-shaped; main stem extending anteriorly from mesial excretory pore at posterior end of body, forking at level of posterior border of vitellaria, extending to level of testes. Flame cell pattern 2 $[(2+2)+(2+2)]=16$.

HOSTS: *Procyon lotor* (L) [type host] and *Rattus rattus* (L), [natural hosts]; *Mus musculus albinus* (ICR strain), *Rattus norvegicus albinus* (Sprague-Dawley strain), *Felis domesticus, Cavia porcellus, Microtus montanus* and *Sigmodon hispidus,* [laboratory hosts].

LOCATION: Small intestine.

TYPE LOCALITY: Mouth of the Mississippi River at Pass a Loutre, Louisiana.

HOLOTYPE: U. S. Nat. Mus. Helminthological Coll. No. 70428.

Carneophallus choanophallus is distinguished from the other species of the genus by the collared male papilla and the prominent follicles of the vitellaria extending from the tip of two ceca, a position well anterior to the acetabulum, to past the testes well into the posterior region of the body. The very short prepharynx, even in extended living worms, distinguishes it from all types except *C. turgidus* Leigh, 1958.

Growth in Different Hosts

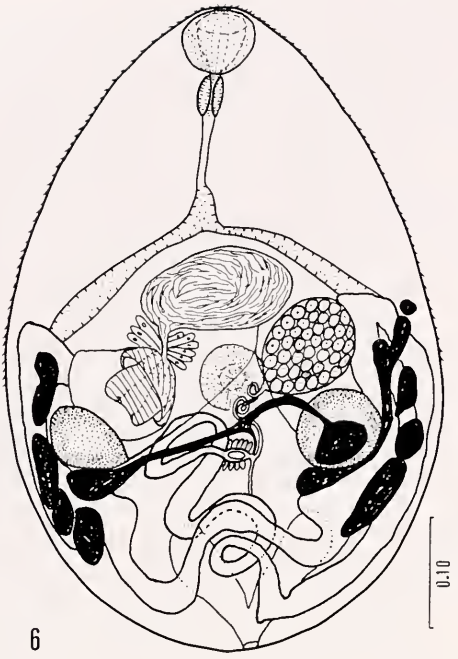
An attempt was made to determine if growth variations occurred within hosts of the same species. Four groups of 6 to 12 laboratory white mice (ICR strain) were fed approximate numbers of *C. choanophallus* metacercariae from natural infections of *M. ohione,* and the mice were sacrificed 48 hr (2 days), 5 days and 25 days post-infection. The worms were removed from the intestine, killed in hot water, fixed in alcohol-formalin-acetic acid, stained and mounted in Permount® for measurement. Computations were based upon measurements of 20 worms for each determination. The comparative similarity of organ sizes is illustrated in Figure 13, in which the body length and width, oral and ventral sucker width and ovary length are compared. The ovary decreased in size as the worm aged.

For intraspecific infections, laboratory white rats (Sprague-Dawley strain) and mice, a laboratory domestic cat, a raccoon (*Procyon lotor*) and a frog (*Rana pipiens*) were used. The raccoon was obtained from the Audubon Park Zoo, where it had been maintained for at least two months. However, it was kept in the laboratory 30 days before use in this experiment at which time it was assumed to be free of *C. choanophallus* infection as preliminary studies with other animal hosts had shown that these short-term infections last no longer than 30 days in the laboratory. The other animals (laboratory reared) were assumed to be free of *C. choanophallus.* The hosts were fed approximate numbers of metacercariae from naturally infected *M. ohione,* and were sacrificed 48 hr post-infection with the exception of the frog. Since *C. choanophallus* does not become ovigerous in frogs maintained at room temperature, a frog was placed in an incubator at 37 C for 15 hr post-exposure after which time it yielded ovigerous adults from the small intestine.

Organs which showed the least amount of variation in dimension were the pharynx and the male copulatory organ. The significant variations in measurements are illustrated in Figure 13. It is seen that for these determinations the adult worms from the white rat and the raccoon were significantly and consistently smaller than those from the mouse and the cat. The causative factors for this difference are not known, but the rat and the raccoon have been found to be the natural definitive hosts. Since the differing dimensions noted are comparatively minor and the genital atrium and male copulatory organ showed no significant variation in dimension or morphology as a result of host variation, the specific diagnosis of *C. choanophallus* is considered to be taxonomically valid.

Longevity of Infection in the Laboratory Mouse

To determine the longevity of *C. choanophallus* infections, 72 mature adult laboratory white mice of the ICR strain (sexes equally divided) were each fed 50 metacercariae from old natural infections of *Palaemonetes pugio.* The mice were divided into 6 groups of 12 mice each and sacrificed at 5-day intervals post-exposure. The small intestine was removed from each mouse, slit open and scraped into saline in a 10.3-cm petri dish for examination under a dissecting microscope. Searching for and counting the worms as they were removed from the petri dish was done 4 times over a 5- to 6-hr period in order to make sure that all worms freed from the intestinal mucosa had fallen to the bottom of the dish where they could be seen. Preceding each examination, the intestine was again scraped and agitated.



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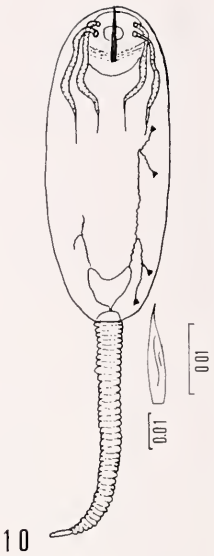

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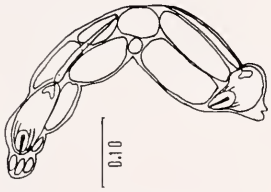

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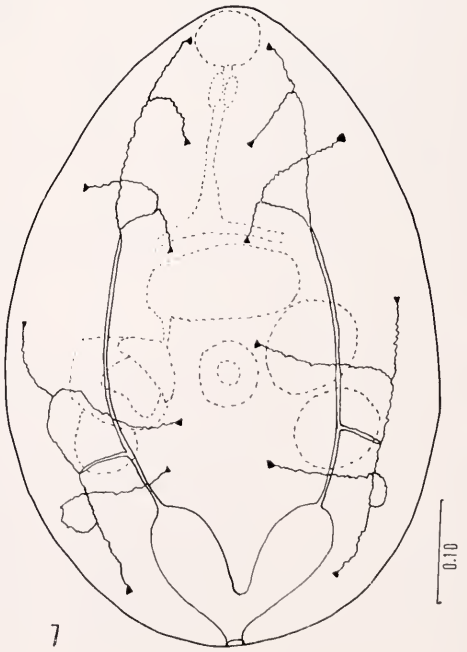

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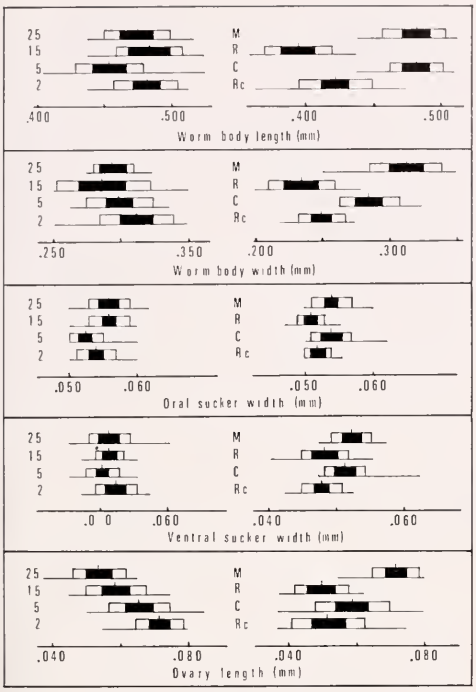

Figure 13. *C. choanophallus* standard length frequency distribution of body length, body width, oral and ventral sucker width, and ovary length (based on 20 hot-water-killed whole mounted specimens per sample). Figures on the left represent 25-, 15-, 5- and 2-day-old infections taken from white mice. Figures on the right represent 48-hr-old infections from white mice (M), white rats (R), a cat (C) and a raccoon (Rc). In each sample the horizontal line indicates the range of the measurements; the cross-bar, the mean; the hollow rectangle, 1 standard deviation on each side of the mean; the solid rectangle, 2 standard errors on each side of the mean.

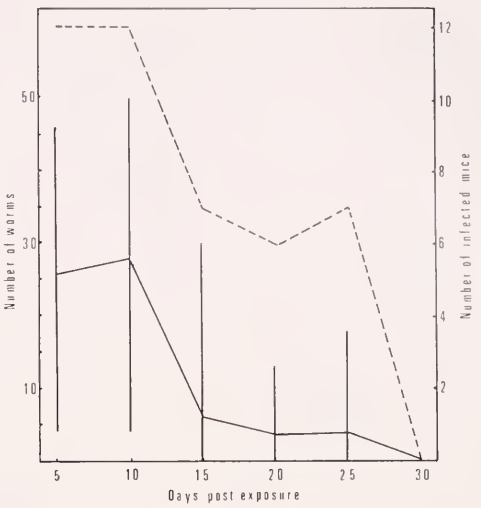

Figure 14. Mean number (_____) and range (vertical lines) of adult *C. choanophallus* from the small intestine, and the number of mice infected (.....) of 6 groups of 12 mice each examined 5 to 30 days post-exposure with 50 metacercariae per mouse.

The results of this experiment are illustrated in Figure 14. On days 5 and 10 post-exposure, all of the mice (24 of 24) were infected with an average of 25 to 28 worms. On the 15-, 20- and 25-day examinations, the number of infected mice was 6 to 7 out of 12, with the average number of worms recovered ranging from 3.5 to 5.8. On day 30, no worms were recovered. Although there were differences between the males and females, these were not considered significant. The general trend was to maintain the infection at a relatively high level for about 10 days, then the density fell to a low level which lasted in some cases up to 25 days but less than 30 days, thus demonstrating the short-term character of infection with *C. choanophallus* in this definitive host. Many of the 15-, 20- and 25-day-old worms were packed with uterine eggs and showed less activity than was observed in the 5- and 10-day infections.

Reinfection of 6 mice 40 days post-exposure resulted in all of the mice becoming infected for a second time, suggesting that previous *C. choanophallus* infections did not make the host refractory to reinfection upon challenge.

The Metacercaria
(Figures 3, 4, and 15-24)

C. choanophallus encysted metacercariae were without exception found embedded in

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Figures 6-12. *Carneophallus choanophallus*. **6**. Adult, dorsal view, drawn from flattened and stained whole mount. **7**. Excretory system, drawn from observations on living excysted metacercariae and adults. **8**. Frontal section of adult genital atrium showing the collared nature of the male papilla. **9**. Egg, taken from the uterus of an adult. **10**. Xiphidiocercaria after emergence from snail. Drawn from living specimen stained with neutral red. **11**. and **12**. Sporocysts from the unspined form of *Lyrodes parvula*.

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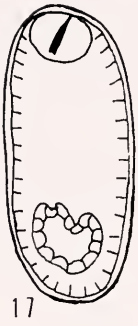
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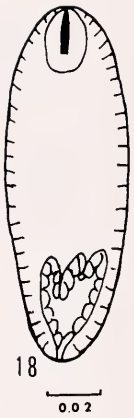
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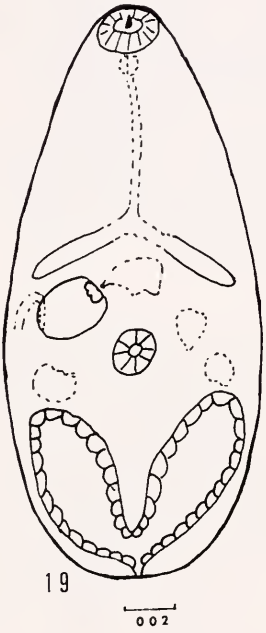
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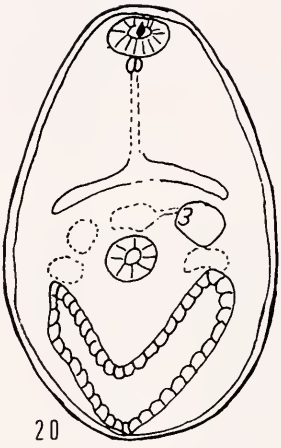
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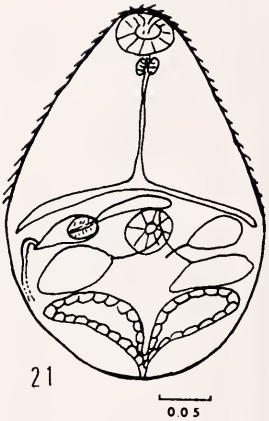
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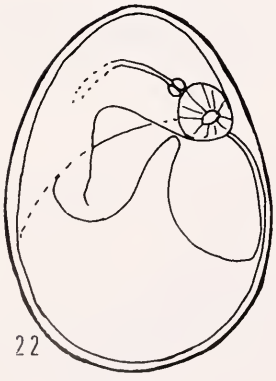
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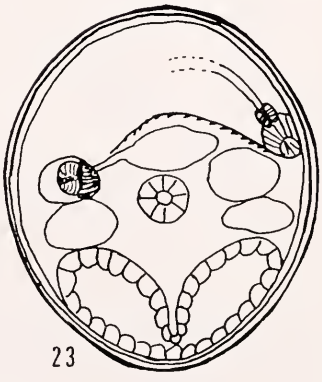
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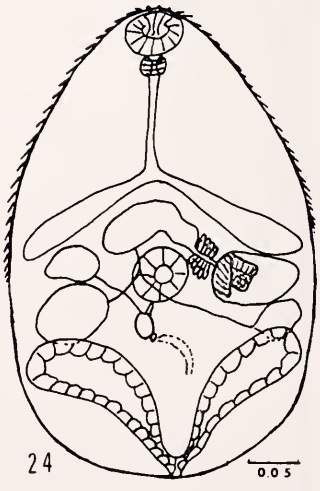
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the shrimp muscle tissue, usually in one or more of the abdominal segments (Fig. 2), occasionally in the cephalothorax and rarely in the appendages.

Infection of the shrimp took place when cercariae from the unspined form of *Lyrodes parvula* entered the gill chamber and penetrated the gill filaments by cutting a slit with the stylet. As the cercaria entered through the slit, its tail became detached and was lost in the current of water passing through the gill chamber. Fourteen shrimp (12 *M. ohione* and 2 *P. pugio*) were observed to be infected by many cercariae in this manner, after which they were placed in an incubator at 27 C.

During the first 18 hr post penetration, the cercariae remained in the gills, and were seen to burrow into the hemocoel. They slowly made their way in the hemocoel to the abdominal musculature where by 24 hr some were found encysted in a very thin and fragile membrane (Fig. 16). The metacercaria, although completely enclosed within this membrane, was seen to be migrating about the hemocoel as it made its way to the abdominal musculature. These newly formed cysts measuring 0.050 by 0.035 in size, grew to 0.090 by 0.040 by 72 hr, and increased in size to 0.095 by 0.050 by 96 hr. At this time, the stylet appeared motile and the oral sucker and excretory vesicle were clearly visible (Fig. 17). Excysted metacercariae of these early stages revealed no additional organs (Figs. 15 and 18). By day 9, the metacercaria contained in its thin (less than 0.002 thick) pliable membrane measured 0.160 to 0.220 long by 0.113 to 0.165 wide (Fig. 20). The cyst wall constantly changed shape as the metacercaria moved about. When the 9-day-old metacercariae were excysted, a remnant of the stylet, the oral and ventral suckers, the pharynx, a small bulbous male papilla surrounded by a thin-walled genital atrium and well-developed excretory vesicles as well as the anlagen of the digestive and reproductive organs appeared visible (Fig. 19). By day 18, the metacercariae measured 0.360 to 0.375 long by 0.240 to 0.245 wide. The cyst wall appeared less pliable and measured 0.002 thick (Fig. 22). All the organs usually seen in metacercariae except the vitellaria and the uterus were observed in the excysted metacercaria although they were reduced in size. Cuticular spines were first observed at this stage. The phallus appeared as a small unlobed muscular bulb within the genital atrium (Fig. 21). On day 23, the encysted metacercariae measured 0.335 to 0.345 long by 0.290 to 0.300 wide. The cyst wall was composed of two membranes, the outer one measured 0.003 and the inner one less than 0.002 thick (Fig. 23). The excysted metacercariae (0.445 to 0.455 long by 0.265 to 0.275 wide) demonstrated clearly the well-developed organs of the preadult metacercaria except for the vitellaria. The collar lobe of the phallus was seen to be developing (Fig. 24).

By day 30, the metacercariae were infective to definitive hosts. At this stage, the excysted metacercariae contained small vitelline follicles and the seminal vesicles were filled with motile sperm. It is suggested that until the vitellaria appear, the metacercariae will not survive in the definitive host, as 4 of 4 attempts to infect mice with young cysts before this stage failed. The encysted metacercariae measured 0.325 to 0.375 long by 0.240 to 0.285 wide. The cyst wall was composed of an inner membrane 0.005 thick and an outer thicker granular wall 0.007 to 0.010 thick. The excysted metacercariae moved about in good condition much as the adults, and measured 0.450 to 0.550 long by 0.305 to 0.320 wide, similar to the adults. In further development, no change was seen in the excysted metacercariae. The size of the encysted metacercariae within the inner membrane apparently reached maximum size about day 30 at 27 C. As time passed, the outer granular layer of the cyst developed into an outer fibrous coat 0.040 to 0.060 thick, external to an extremely tough inner hyaline layer 0.010 to 0.015 thick (Figs. 3 and 4). Encysted metacercariae in *M. ohione* have been main-

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Figures 15-24. *Carneophallus choanophallus* staged development of metacercaria in *Macrobrachium ohione*. (All figures were drawn from living material.) **15-16**. 24-hr stage in gills and muscle, 15 excysted, 16 encysted. **17-18**. 96-hr stage in muscle, 17 encysted, 18 excysted. **19-20**. 9-day stage, 19 excysted, 20 encysted. **21-22**. 18-day stage, 21 excysted, 22 encysted. **23-24**. 23-day stage, 23 encysted, 24 excysted.

TABLE 2.
Incidence and density of infection of different size classes of *Macrobrachium ohione* by *Carneophallus choanophallus* from September, 1966 to November, 1967.[1]

Shrimp Size Class	Numbers of Shrimp: Number of Metacercariae 0	1–10	11–20	21–30	31–40	41–50	51–60	Incidence of Infection[2]	Incidence of Infection: Class	Incidence of Infection: Total Sample	Frequency of Size Class (%) Total Samp.	Total Number of Cysts
20–24	2	–	–	–	–	–	–	0/2	–	–	0.02	–
25–29	23	1	–	–	–	–	–	1/24	4.16	0.01	0.24	1
30–34	15	2	–	–	–	–	–	2/17	11.76	0.02	0.17	5
35–39	60	11	–	–	–	–	–	11/71	15.49	0.11	0.71	18
40–44	560	138	4	2	–	1	–	145/705	20.56	1.45	7.05	437
45–49	1330	420	20	6	3	2	2	460/1790	25.69	4.60	17.91	1804
50–54	1485	489	23	14	4	1	2	533/2018	26.41	5.33	20.19	2376
55–59	1449	392	21	5	2	–	1	421/1870	22.51	4.21	18.71	1504
60–64	1191	306	18	2	1	–	–	327/1518	21.54	3.27	15.18	1071
65–69	787	184	10	2	3	1	1	201/988	20.34	2.01	9.88	859
70–74	438	96	1	2	–	–	–	99/537	18.43	0.99	5.37	264
75–79	177	33	–	1	–	–	–	34/211	16.11	0.34	2.11	92
80–84	107	5	–	–	–	–	–	5/112	4.46	0.05	1.12	13
85–89	131	–	–	–	–	–	–	0/131	–	–	1.31	–
TOTAL	7755	2080	97	34	13	5	6	2239/9994				8444
% of Total Sample	77.9	20.8	.97	.34	.13	.05	.06	22.4/100.0			Mean No. Cysts per Shrimp	0.84

[1] Collections made from the Mississippi River at Ama, Louisiana.
[2] Number of infected shrimp/number of shrimp in specified class.

tained in the laboratory in good condition for up to six months when the shrimp died.

Excystment of the young metacercariae in the laboratory was easily done by simply pricking the thin pliable cyst membrane and teasing the worm out. By the time the fibrous and hyaline layers developed, considerable time and patience was needed to break the tough membranes mechanically. If the cysts were placed in saline at room temperature for 4 to 5 hr, bacterial and perhaps chemical activity would weaken the walls so that excystment was easily done with a sharp needle. With longer time, the worms were usually able to excyst without mechanical assistance.

Geographical Distribution of Infections in M. ohione

During the summer of 1967, a geographical survey of the *M. ohione* infected with *C. choanophallus* metacercariae was conducted in 4 Louisiana rivers. Shrimp collections were made using traps and by dredge-trawling behind a small outboard motor boat. A summary appears in Table 1. The West Pearl River yielded no *M. ohione,* however, infected *P. pugio* were found in great abundance in the brackish water marshes near its entrance into Lake Borgne. *M. ohione* from the Red River were uninfected. From the Atchafalaya River, 2 collections were made upstream from Morgan City, Louisiana. One shrimp harbored a single metacercaria, therefore, the incidence is considered to be very light. In the Mississippi River, the incidence and intensity of infection was found to be relatively constant from Ama, Louisiana (mile 115) to Greenville, Mississippi (mile 540). The incidence and intensity of infection increased in stations downstream from Empire, Louisiana (mile 30). The increase in the first intermediate host, the unspined form of *Lyrodes parvula,* and the definitive host populations near the mouth of the Mississippi River where great expanses of fresh to brackish water marshes and ponds containing *Cabomba* spp., *Alternanthera* spp. (alligator weed) and *Spartina* spp. (marsh grass) remote from disturbances by humans offer the best explanation for the high incidence and intensity of infection of *M. ohione* with *C. choanophallus* metacercariae in these areas.

Incidence and Density of Infection in M. ohione Over a 15-Month Period at Ama, Louisiana

From September, 1966 to November, 1967, systematic biweekly collections of *M. ohione* were made from the west bank of the Mississippi River near the ruins of the old Sellers Plantation House at Ama, Louisiana. During this 15-month period, a total of 9,994 shrimp were captured. Of these, 2,239 (22.4 per cent) were observed under a dissecting microscope to harbor from 1 to 60 metacercariae. Two thousand eighty (20.8 per cent) shrimp harbored 1 to 10 cysts, leaving only 155 (1.5 per cent) shrimp harboring 11 to 60 cysts. Cysts usually occurred in the transparent abdominal musculature, but were also seen in the muscles of the cephalothorax. The trapped shrimp ranged in size from 20 to 85 from the tip of the rostrum to the tip of the telson. The infected shrimp ranged from 25 to 80 in length. The 50 to 54 size class contained the largest number of shrimp in the sample. This size class also showed the greatest incidence and density of infection. The mean density of infection for the total sample was 0.84 metacercariae per shrimp (Table 2).

Figure 25 shows the per cent of infected shrimp compared with the per cent of the total sample by size classes. It is apparent that the incidence of infection with *C. choanophallus* metacercariae is proportional to the percentage of all shrimp in the size classes for the 15-month period. These curves are typical for any month during the collecting period.

Monthly standard length frequency distributions of the uninfected and infected shrimp (Fig. 26) demonstrate that there are variations in these categories during the 15-month sampling period. Graphic representation of the data (Fig. 27) shows that during the months of January to April, the mean sizes of the uninfected shrimp were less than the infected shrimp. In March and April, overlapping took place, and for the remainder of the study time, the mean size of the uninfected shrimp was greater than the infected shrimp. This disparity was more noticeable during the months of May to August.

Figure 27 shows that during the 15-month collecting period there were two maxima

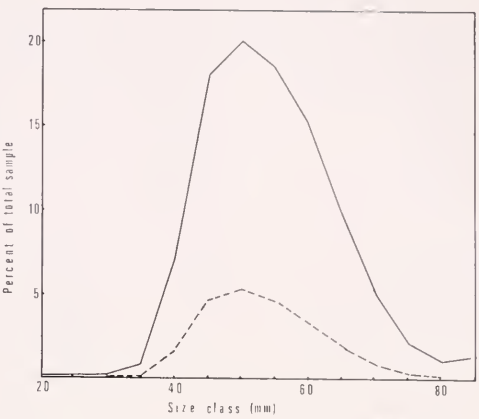


Figure 25. Incidence of infected *M. ohione* (.....) compared with the per cent of the total sample (_____) by size classes for collections made September, 1966 to November, 1967 at Ama, Louisiana.

(November and July) and two minima (January and September) in the mean sizes of the shrimp sample. This suggests two breeding periods. Female shrimp in berry were collected beginning in April and ending in September. As the young shrimp began to appear in the collection samples, the mean size decreased. Growth of the shrimp is indicated by the increase in the mean shrimp size. The greatest growth occurred in the spring.

Figure 28 shows the mean density per shrimp of the total sample compared with the incidence of infection for the collection period. Two maxima (spring and fall) and two minima (winter and summer) are noted with the summer to fall disparity being the greatest. The maximum density and incidence occurred in the early fall. Examination of Figures 27 and 28 together shows that when the sample was of maximum shrimp size (composed of larger shrimp), the density and incidence were minimal. This suggests that recruitment in the shrimp population took place at these times (November to January and June to August), and that these young uninfected shrimp did not appear infected in the collection samples until approximately a month later.

There seem to be two periods of shrimp growth, both of which were accompanied by a decrease in the incidence and density of infection by *C. choanophallus* metacercariae.

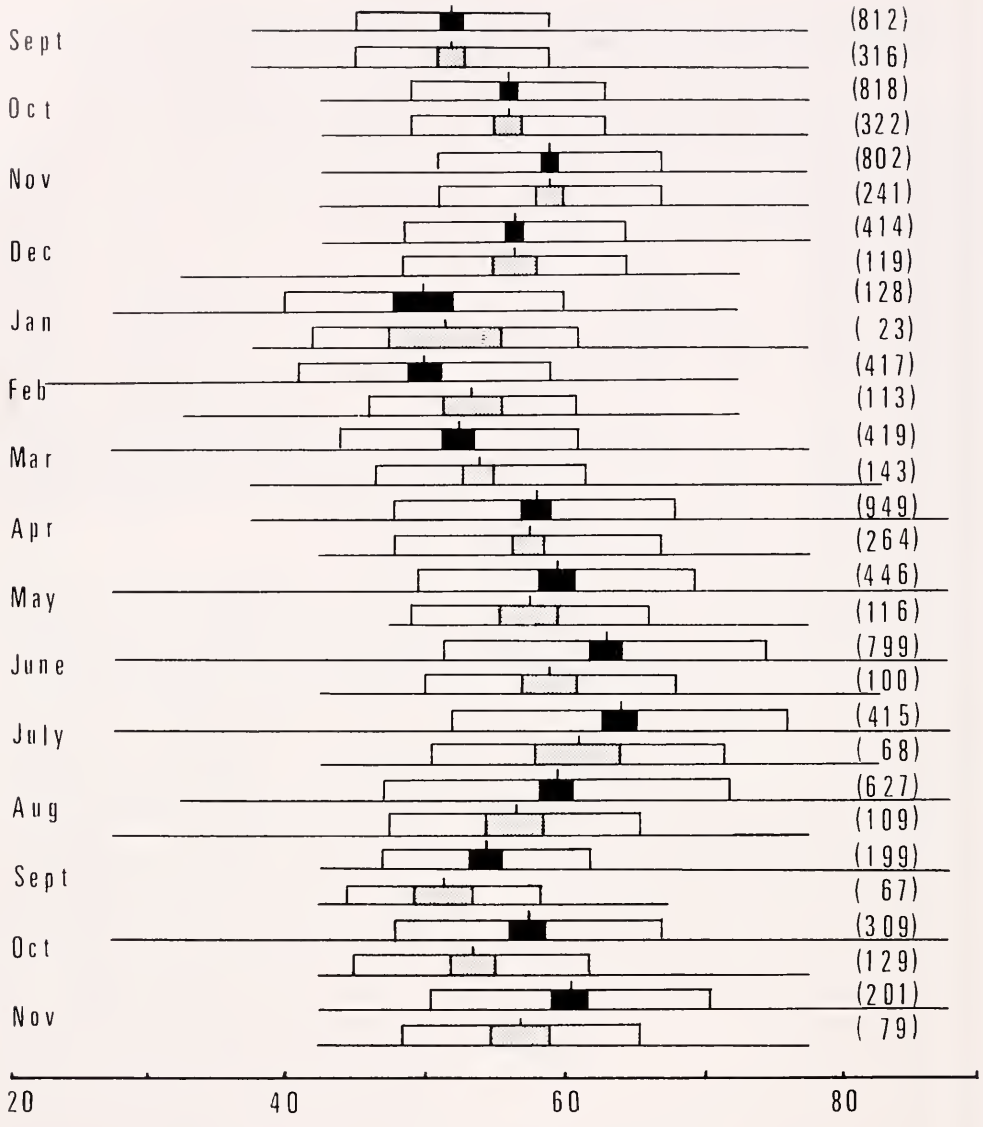
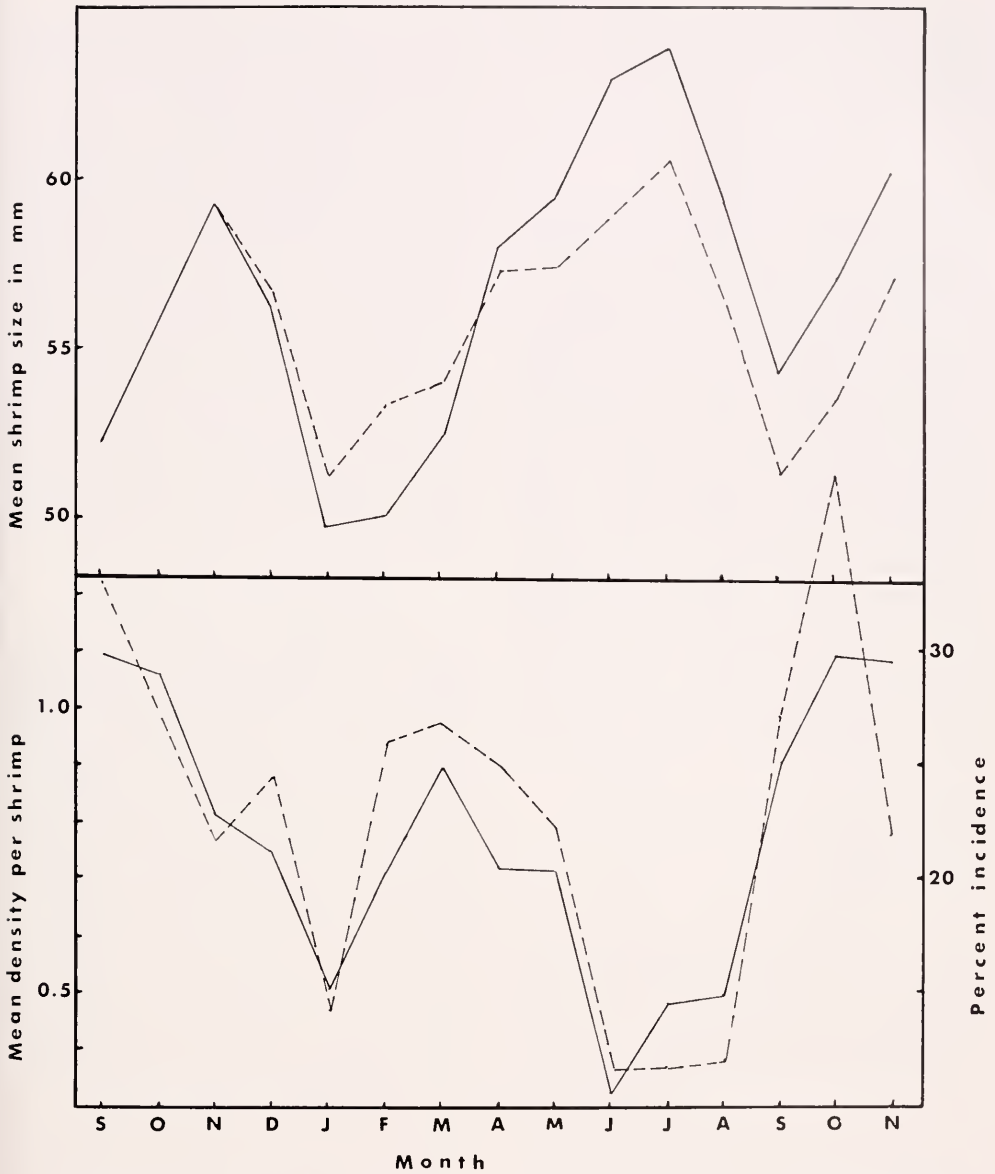


Figure 26. Standard length frequency distribution of uninfected (□■□) and infected (□▨□) samples of *M. ohione* collected at Ama, Louisiana, September, 1966 to November, 1967. In each sample the horizontal line indicates the range of the measurements; the crossbar the mean; the hollow rectangle, 1 standard deviation on each side of the mean; the solid or dotted rectangle, 2 standard errors on each side of the mean. Figures in the parentheses equal the number of shrimp in the sample.

The growth periods are followed by an influx of young shrimp into the sample accompanied by an abrupt rise in the incidence and density of the infected shrimp approximately a month later. This biseasonal increase indicates that most infections probably occurred early in the life-cycle of the shrimp, but it does not preclude the possibility that infection of the shrimp occurred continuously throughout



Figures 27-28. 27. Above. Monthly mean size of the uninfected (_____) and infected (_ _ _ _) *M. ohione*. 28. Below. Monthly incidence (_____) and mean density (_ _ _ _) of the sample of *M. ohione*. Collections were made at Ama, Louisiana September, 1966 to November, 1967.

the year. Observations indicated that the conditions for infection of juvenile shrimp, which live in shallow relatively still water where the unspined form of *Lyrodes parvula* exists, appear to be more likely than those for the adult shrimp, which live in deeper swift moving currents. Laboratory experiments showed that large and small *M. ohione* are both 100 per cent susceptible to *C. choanophallus* cercariae and that superinfection takes place.

The pathological effects of infection on the shrimp are not clear. The larger mean size classes of the uninfected shrimp versus those

of the infected shrimp for June and July suggest that infection interfered with growth, or that mortality was higher in infected shrimp.

The Cercaria
(Figure 10)

Small "monostome" xiphidiocercaria with the characters of the Ubiquita group. The following dimensions were determined using living cercaria, stained with neutral red or Nile-blue sulfate. Body 0.075 to 0.120 long by 0.035 to 0.055 wide, ovoid to elongate. Tail 0.060 to 0.110 long by 0.010 to 0.015 wide at base, with fine cuticular annulations. Oral sucker 0.020 to 0.025 in diameter. Stylet 0.015 to 0.017 long by 0.004 wide, base squared, shaft cylindrical then tapered to slightly ventrally directed point. Digestive system not observed. Two thin pairs of penetration gland cell ducts 0.020 to 0.030 long by 0.003 to 0.005 wide, opening into the anterior portion of the oral sucker lateral to stylet; the lateral gland cell ducts opening posterior to the mesial gland duct apertures. Cystogenous glands not prominently visible. Excretory vesicle U-shaped. Excretory formula 2 [(1 + 1) + (1 + 1)]. Develop in oval or elongate sporocysts containing about 10 to 15 cercariae.

HOST: *Lyrodes parvula* Guilding, 1928 (unspined form).

TYPE LOCALITY: Pass a Loutre, Louisiana.

The cercaria of *C. choanophallus* in general resembled other microphallid larvae but differed from the cercariae of the genus *Microphallus* in the possession of only two pairs of penetration glands and in the molluscan host. The stylet was symmetrical in dorsal aspect but asymmetrical when viewed from the side. The cystogenous gland cells were seen only in cercariae which had emerged from the snail several hours before examination.

Emergence of the cercariae was accomplished by placing the snail in water with the salinity matching that of the field collection site and then slightly elevating the temperature under an electric light bulb. Emergence into water of the incorrect salinity either did not occur, or occurred very lightly and resulted in weakened short-lived cercariae. Normally the cercariae lived up to 48 hr.

Upon emergence, the cercariae swam almost continuously with the posterior part of the body flexed ventrally and the tail lashing vigorously in S-shaped movements. These swimming movements served the purpose of keeping the cercaria suspended in the water off the bottom of the container. If the water was jarred by movement of the container or by touching the surface with a probe, the cercariae stopped swimming for a moment during which time the body would extend and contract once or twice before swimming was resumed. This type of activity aided the cercariae as they were drawn into the gill chamber of the shrimp for penetration of the gills. Contact with the gill filaments stimulated the movements of the stylet as it slashed an opening through which the squirming cercaria penetrated the shrimp.

The Daughter Sporocyst
(Figures 11 and 12)

There are probably two sporocyst generations of *C. choanophallus* in the unspined form of *Lyrodes parvula,* but only the cercaria producing one was observed in the naturally infected snails studied in the laboratory. Out of 200 of the unspined form of *L. parvula* from a locality in which virtually 100 per cent of the *P. pugio* were densely infected, 13 snails (6.5 per cent) were observed to contain *C. choanophallus* cercariae and sporocysts when crushed. The sporocysts were mostly elongate, but some were saccate in shape. They contained 10 to 15 cercariae usually with two of the cercariae ready for release; the others being in various stages of development. The birth pore was terminal as under light cover glass pressure, cercariae were seen to emerge from this position. The opposite end of the sporocyst contained many small rounded structures considered to be developing cercariae and germ balls.

The snails examined contained from 5 to more than 40 sporocysts. Counting beyond 40 was difficult as the sporocysts broke up so that they could not be clearly identified for counting. Since four of the crushed snails were seen to contain more than 200 cercariae, it might be assumed that these snails may have contained more than 40 sporocysts.

The sporocysts measured 0.045 to 0.350 long by 0.020 to 0.080 wide.

The Eggs and Miracidium (Figure 9)

The process of egg formation in the adult worm was observed to be similar to that described by Cable and Hunninen (1940). Three hours post-exposure the adult worms contained a few (1 to 10) eggs in laboratory rats and mice. As seen earlier, it appears that the longer the worm stays in the intestine of the definitive host, the larger the number of eggs found in the uterus.

For egg studies the uteri of 72-hr worms from mice infections were used. Whole worms were cultured in stendor dishes of saline and dechlorinated tap water at room temperature for daily observation. Every other day the water was changed and any debris from the dead worms was removed.

Development of all cultures was as follows: On day 1, the eggs measured 17-18 microns long by 9-11 microns wide. The operculum was clearly visible. Living cells in the process of dividing were observed near either end of the egg. On day 5, the contents of the egg appeared to be divided into sections or clumps. By day 10, a miracidium with the anterior end directed against the operculum was observed. At this stage, it was estimated that 75 per cent of the eggs were viable. By day 15, there seemed to be no change in the appearance of the miracidium. No free swimming miracidia were observed.

Infection of the unspined form of *Lyrodes parvula* by *C. choanophallus* was accomplished by casting whole ovigerous worms, taken from 7 to 20-day mice and rat infections, into aquaria containing the snails. The snails had been collected in a pond at Bonnet Carre Spillway, St. Charles Parish, Louisiana. Two hundred snails were crushed, examined, and judged to be uninfected. Another 200 snails from this collection were exposed and kept in 2 large finger bowls containing dechlorinated water, *Cabomba* spp. and *Alternanthera* spp. Five months later 16 snails survived. Of the survivors, 8 (50 per cent) were infected with *C. choanophallus* sporocysts containing cercariae. It is believed that the high percentage of infection in the surviving snails was the result of the laboratory exposures.

Carneophallus from *Callinectes sapidus*

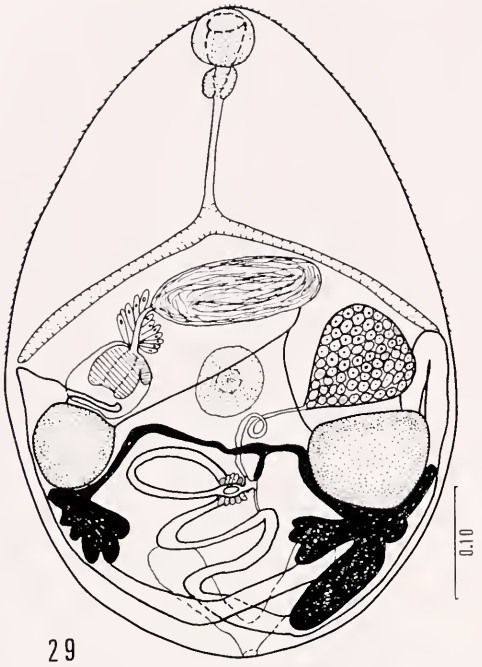
The Life-Cycle

While searching the Pass a Loutre area for the snail harboring the cercaria of *Carneophallus choanophallus* during the summer of 1967, the spined form of *Lyrodes parvula* was found. These snails when brought into the laboratory produced large numbers of a small xiphidiocercaria of the Ubiquita type which fit the suspected description of *Carneophallus* cercariae. The snails also came from a known endemic area. Since many unsuccessful attempts were made to infect *Macrobrachium ohione* with this cercaria, other possible second intermediate crustacean hosts from the Pass a Loutre area were brought into the laboratory for examination. Of these, the blue crabs, *Callinectes sapidus*, for this collection, were found to be 100 per cent infected in the hepatopancreas and muscles with microphallid type metacercariae. When these metacercariae were excysted or fed to rats and mice, the resultant trematodes were found to exhibit the characters of the genus *Carneophallus* Cable and Kuns, 1951. A detailed study of these worms revealed the discovery of a second new species of *Carneophallus*.

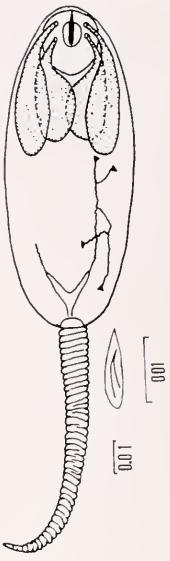
As the cercariae from the spined form of *L. parvula* were suspected of infecting the blue crabs from Pass a Loutre, a search was made to find a locality with a population of blue crabs uninfected or very lightly infected with *Carneophallus* spp. of metacercariae. Such a population was located 12 miles west of the Mississippi River bridge on U. S. Highway 90 at the Osgood and Willswood ponds. Ten of these crabs were exposed to cercariae from the spined form of *L. parvula* resulting in medium (50 or more metacercariae) to heavy (100 or more metacercariae) infections whereas the thirty unexposed crabs were either negative or harbored a maximum of three older metacercariae.

In the Pass a Loutre area, all raccoons, *Procyon lotor* (L), examined harbored large numbers of *C. choanophallus* and the second new species. Several birds were also examined but none of these harbored *Carneophallus* spp. No other suspected natural definitive hosts in this area were examined.

The life-cycle is as illustrated in Figure



29



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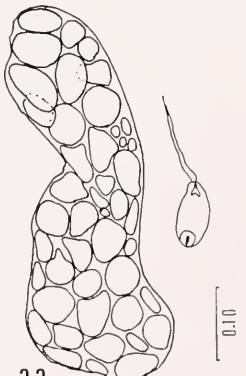

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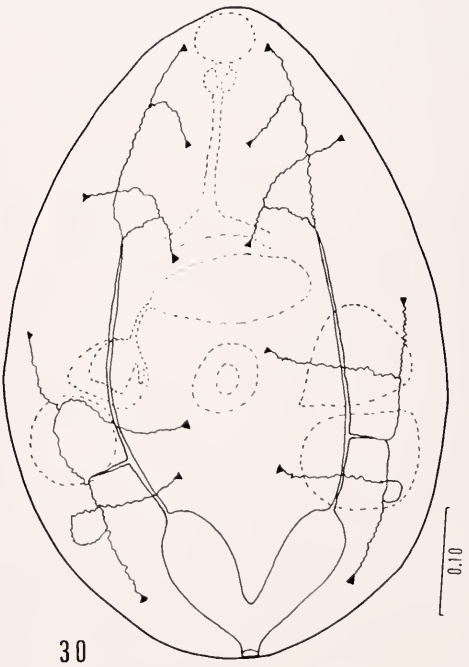

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31

5 B. The natural definitive host was the raccoon, *Procyon lotor* (L), but possibly other mammals may also serve. The first intermediate host was a snail *Lyrodes parvula* Guilding, 1828 (spined form). The second intermediate host was the blue crab, *Callinectes sapidus* Rathbun, 1896.

Description of the Stages of the Life History of Carneophallus **basodactylophallus** n. sp.

The Adult (Figures 29-30)

SPECIFIC DIAGNOSIS: [based on 10 hot water-killed, unflattened specimens from *Rattus norvegicus albinus* (Sprague-Dawley strain) and *Mus musculus albinus* (ICR strain)]. Microphallidae; *Carneophallus*. Body pyriform, sometimes with posterior notch, 0.415 to 0.455 long by 0.285 to 0.330 wide. Forebody 0.187 to 0.212 long. Integument of anterior 1/2 of body spined. Oral sucker subterminal, 0.050 to 0.062 long by 0.050 to 0.062 wide. Prepharynx almost absent. Pharynx 0.022 to 0.025 long by 0.022 to 0.027 wide. Esophagus extending from pharynx to approximately anterior 1/3 body, 0.087 to 0.110 long. Ceca two, extending posteriorly and obliquely from cecal bifurcation at posterior end of esophagus, 0.125 to 0.152 long. Acetabulum equatorial, mesial, 0.052 to 0.065 long by 0.052 to 0.062 wide. Sucker ratio 1:1.02 to 1.07.

Genital pore sinistral to acetabulum, followed by genital atrium approximately 1.25 times diameter of acetabulum. Testes two, side by side in posterior 1/3 body, edges smooth, oval in outline: dextral testis 0.022 to 0.052 long by 0.065 to 0.095 wide; sinistral testis 0.027 to 0.050 long by 0.050 to 0.095 wide. Vas deferens joining anterior to acetabulum, connecting with dextral posterior margin of seminal vesicle. Seminal vesicle club-shaped, preacetabular, transverse to longitudinal axis of body, tapered to form slender sperm duct surrounded by prostate gland cells at distal tip. Sperm duct connecting with fleshy intra-atrial genital papilla (0.060 to 0.062 long by 0.030 to 0.045 wide) with small posterior basal flap. Ovary between seminal vesicle and dextral testis; oval to oblong in outline, edges lightly lobed, 0.052 to 0.075 long by 0.050 to 0.075 wide. Uterus descending from mesial intertesticular Mehlis' gland to fill posterior body, ascending along body wall to posterior tip of dextral cecum, descending to posterior body, ascending along body wall to posterior tip of sinistral cecum, connecting with slightly enlarged metraterm surrounded by gland cells which in turn connects with genital atrium. Vitellaria composed of 6 to 11 coarse follicles on each side of body, extending from posterior ends of ceca to posterior 1/8 body. Uterine eggs operculate, 16-17.5 microns long by 10-12 microns wide. Excretory vesicle V-shaped; main stem extending anteriorly from mesial excretory pore at posterior end of body, forking at level of testes. Flame cell pattern 2 [(2+2) + (2+2)] = 16.

HOSTS: *Procyon lotor* (L) (type host) [natural host]; *Rattus norvegicus albinus* (Sprague-Dawley strain) and *Mus musculus albinus* (ICR strain), [laboratory hosts].

LOCATION: Small intestine.

TYPE LOCALITY: Mouth of Mississippi River at Pass a Loutre, Louisiana.

HOLOTYPE: U. S. Nat. Mus. Helminthological Coll. No. 70430.

Carneophallus basodactylophallus is distinguished from the other species of the genus by the small posterior flap on the base of the male papilla. The very short prepharynx, even in extended living worms, distinguishes it from all types except *C. turgidus* Leigh, 1958 and *C. choanophallus*.

The Metacercaria

C. basodactylophallus metacercariae were found encysted in the hepatopancreas and muscle tissue of the cephalothorax and all the appendages of the blue crab *Callinectes sapidus* Rathbun, 1896. They are morphologically similar to *C. choanophallus* metacercariae.

←

Figures 29-33. *Carneophallus basodactylophallus*. **29.** Adult, dorsal view, drawn from a flattened and stained whole mount. **30.** Excretory system, drawn from observations on living excysted metacercariae and adults. **31.** Frontal section of the adult genital atrium showing the posterior basal flap of the male papilla. **32.** Xiphidiocercaria after emergence from snail. Drawn from living specimen stained with neutral red. **33.** Sporocyst from the spined form of *Lyrodes parvula*.

Laboratory infections of the blue crab took place when cercariae from the spined form of *Lyrodes parvula* were allowed to enter the gill chamber where penetration of the gills took place. Ten of ten (100 per cent) exposed crabs became moderately (50 or more metacercariae) to heavily (100 or more metacercariae) infected versus two of thirty (6.6 per cent) of the controls which were found to be very lightly (1 to 3 metacercariae) infected. Migration of the cercariae in the crab hemocoel was not observed. However, the cercariae wriggled their way to the hepatopancreas and the muscle where encystment took place in thin membranes.

Development of *C. basodactylophallus* in the blue crab seemed to be slower than *C. choanophallus* in shrimp, since after 40 days post-exposure at room temperature the thickened cyst wall of the metacercaria had not yet developed.

Newly formed encysted metacercariae measured 0.050 by 0.035 in diameter. Fully developed metacercariae measured 0.330 to 0.360 long by 0.325 to 0.355 wide. The cyst wall was composed of an inner membrane 0.005 thick and an outer hyaline layer 0.010 to 0.015 thick surrounded by a thick fibrous coat 0.040 to 0.060 thick.

Of the geographical areas checked, the incidence of infection at Pass a Loutre was 85 per cent, and 9.2 per cent at the Willswood and Osgood ponds. Ten crabs taken from the canals of the Bonne Carre Spillway were all negative for *C. basodactylophallus*.

The Cercaria
(Figure 32)

Small "monostome" xiphidiocercaria with the characters of the Ubiquita group. The following dimensions were determined using living cercariae stained with neutral red and Nile blue sulfate. Body 0.080 to 0.120 long by 0.040 to 0.066 wide, ovoid to elongate. Tail 0.060 to 0.110 long by 0.010 to 0.015 wide at base with fine cuticular annulations. Oral sucker 0.025 to 0.030 in diameter. Stylet 0.012 to 0.015 long by 0.004 wide, base rounded, shaft cylindrical then tapered to slightly ventrally directed point. Digestive system not observed. Two thick pairs of penetration gland cell ducts, lateral pair 0.035 to 0.040 long by 0.009 to 0.012 wide, mesial pair 0.030 to 0.035 long by 0.007 to 0.009 wide, opening into anterior portion of oral sucker lateral to stylet, lateral gland cell ducts opening anterior to mesial duct apertures. Cystogenous gland cells not prominently visible. Excretory vesicle U-shaped. Excretory formula 2 [(1 + 1) + (1 + 1)]. Develop in oval or elongate sporocysts containing about 40 to 60 cercariae.

HOST: *Lyrodes parvula* Guilding, 1828 (spined form).

TYPE LOCALITY: Pass a Loutre, Louisiana.

The cercariae of *C. basodactylophallus* closely resemble those of *C. choanophallus*. The notable differences were the shorter stylet with its rounded base, the enlarged penetration gland cell ducts, and the snail host; the spined form of *L. parvula* for *C. basodactylophallus*. The cercariae were incapable of producing metacercariae in *M. ohione*. Conditions for emergence and subsequent activity of the cercariae appear to be similar to *C. choanophallus*.

The Daughter Sporocyst
(Figure 33)

There are probably two sporocyst generations of *C. basodactylophallus* in the spined form of *Lyrodes parvula*, but only the cercariae producing one was observed in naturally infected snails studied in the laboratory. Of 100 spined forms of *L. parvula* from Pass a Loutre, 2 were observed to contain *C. basodactylophallus* cercariae when crushed. The sporocysts were elongate to saccate in shape. They contained from 40 to 60 cercariae, many of which were ready for release. The birth pore was terminal.

The snails examined contained 5 and 30 sporocysts which measured 0.400 to 0.550 long by 0.150 to 0.300 wide. The sporocysts of *C. basodactylophallus* were longer and contained more cercariae than those of *C. choanophallus*.

The Eggs and Miracidium

Morphologically, the eggs of *C. basodactylophallus* could not be distinguished from those of *C. choanophallus*. Measurements were 17-18 microns long by 9-11 microns wide.

No attempts were made to culture the eggs and miracidia were not observed.

Discussion

The erection of the four sub-families within the Microphallidae (Deblock and Tran Van Ky, 1966) provides a realistic and convenient division of the numerous species of microphallids into related groups based on the morphology of the copulatory structures. Following Cable and Kuns (1951) the sub-family Maritreminae (Lal, 1939) Deblock and Tran Van Ky, 1966 would be considered primitive. The sub-family Microphallinae Ward, 1901 could have arisen as one stem from Maritreminae. Evolution in this case is suggested to have proceeded from the primitive forms possessing a cirrus and cirrus sac to forms in which these structures are lost. This loss is thought to be the result of evolutionary modification resulting in the numerous morphological variations of the genital atrium and male papilla presently demonstrated by these forms. The sub-families Gynaecotylinae Guschanskaia, 1952 and Sphairiotreminae Deblock and Tran Van Ky, 1966 may be thought of as having arisen as another stem from a more primitive source or from the Maritreminae as a result of evolutionary modification to a vesiculo-prostatic sac which replaced the cirrus pouch.

The discussion in this paper is concerned with the development of the genera and their species within the sub-family Microphallinae Ward, 1901. Biguet, Deblock and Capron (1958) have continued to follow the reasoning of Cable and Kuns (1951) in their listing of four genera of the Microphallinae (*Leninseniella* Stiles and Hassal, 1901; *Spiculotrema* Belopolskaia, 1949; *Microphallus* Ward, 1901; *Endocotyle* Belopolskaia, 1952) based upon the morphological attributes of the genital atrium and its contained male copulatory papilla. Biguet, Deblock and Capron (1958) considered the genus *Carneophallus* Cable and Kuns, 1951 redundant. They argued that lobation of the male copulatory organ although a morphological fact, is not significant enough to warrant a separate genus. Cable, Connor and Balling (1960) objected to lumping of heterogeneous groups into the single genus *Microphallus,* contending that the adult morphology alone was not a satisfactory basis upon which to determine the taxonomic relationships of the *Carneophallus* group. This writer agrees with Cable, Connor and Balling (1960) and considers the lumping of the many species listed under the genus *Microphallus,* based not upon shape and form of the phallus but upon its comparative dimensions (Biguet, Deblock and Capron, 1958) to be a deviation from the method used to this point. If the development of a thickened ornamented wall of the genital atrium is considered reason enough for the maintenance of the genus *Levinseniella* (Biguet, Deblock and Capron, 1958), then it also seems logical to separate out those species which have developed a large fleshy-lobed male papilla under the genus *Carneophallus*. Except for a few borderline cases (i.e. *Carneophallus muellhaupti* Coil, 1956 which possesses a lightly lobed male papilla), the lobation of the male papilla is strikingly obvious, illustrating further evolutionary modification of this structure as well as convenient division of a relatively large heterogeneous group of species.

This reasoning has prompted this writer to place the two new species described in this paper into the genus *Carneophallus* Cable and Kuns, 1951. Cable and Kuns (1951) distinguished the genus *Carneophallus* as microphallids with a large unornamented thin-walled genital atrium which is almost filled with a lobed fleshy male papilla, one of the lobes being penetrated by the ejaculatory duct. Using this distinction and the original descriptions, the following twelve species are segregated:

C. trilobatus Cable and Kuns, 1951.
C. pseudogonotylus (Chen, 1944) Cable and Kuns, 1951.
C. muellhaupti Coil, 1956.
C. skryabini Caballero, 1958.
C. turgidus Leigh, 1958.
C. chabaudi (Capron, Deblock and Biguet, 1957) Cable, Connor and Balling, 1960.
C. tringae (Capron, Deblock and Biguet, 1957) Cable, Connor and Balling, 1960.
C. canchei (Biguet, Deblock and Capron, 1958) Cable, Connor and Balling, 1960.
C. bilobatus Cable, Connor and Balling, 1960.
C. lactophrysi Siddiqi and Cable, 1960.
C. choanophallus n. sp.
C. basodactylophallus n. sp.

The specific name, *choanophallus,* indicates the collared nature of the phallus. The

term, *basodactylophallus,* describes a phallus possessing a finger or flap at its base. These two characters distinguish these two new species from all the others.

Further support for the validation of the genus *Carneophallus* is obtained from growth studies in definitive hosts. Baer (1943) and Stunkard (1960) pointed out that growth in microphallids takes place in the second intermediate host, which is usually a crustacean. Staged development of *C. choanophallus* in shrimp demonstrated the remarkable increase in body and organ size that takes place at this stage in the microphallid life-cycle. It follows then that no significant growth takes place in the worm during its short-term infection in the intestine of the definitive host. Minor differences in worm dimensions were noted in worms recovered from different hosts. Such interspecific host growth variations have also been studied by Hunter (1952) for *Gynaecotyla adunca.* Hunter's (1952) observations agree with those of *C. choanophallus* in that in normal hosts the worms were smaller than in abnormal hosts. In the case of *C. choanophallus,* these growth variations are minor, but they tend to cast doubt upon the classification system of Biguet, Deblock and Capron (1958) based upon comparative sizes of the male papilla and the ventral sucker rather than morphology for the species of the genus *Microphallus.* The shape and form of the male papilla, which was seen to be characteristically constant in *C. choanophallus* and *C. basodactylophallus* from all hosts observed, appears to be a character of enough stability to warrant the validation of the genus *Carneophallus.*

Cable (1956) and Cable, Connor and Balling (1960) described differences in stylet and cephalic gland morphology of cercariae which they believed to be of taxonomic significance. Cable, Connor and Balling (1960) for this reason maintained that when the life-cycles of members of the genus *Carneophallus* became known, that additional evidence to support the validity of the genus would appear. The cercariae of both *C. choanophallus* and *C. basodactylophallus* possess only two pairs of cephalic glands. Heard (personal communication) also observed *Carneophallus* spp. cercariae with only two pairs of cephalic glands. Except for the cercaria of *Maritrema caridinae* described by Shibue (1951), all microphallid cercariae are described as possessing four pairs of cephalic glands. It cannot be stated that all *Carneophallus* cercariae possess only two pairs of cephalic glands on the basis of the two cercariae seen out of the possible 12 species of these microphallids known. However, this peculiar difference observed in these two species lends further evidence to support the validity of the genus *Carneophallus* Cable and Kuns, 1951.

Experimental infection of *Macrobrachium ohione* and *Palaemonetes pugio* with cercariae of *Carneophallus choanophallus* demonstrated that this microphallid may utilize more than one species of shrimp as the second intermediate host. *Microphallus minus* Ouchi, 1928 in Japan and China is reported to encyst in three species of shrimp (Ouchi, 1928 and Yeh and Wu, 1951), *Macrobrachium nipponensis, Palaemon asperulus* and *P. nipponensis.* Repeated attempts to infect shrimp with *C. basodactylophallus* cercariae and crabs with *C. choanophallus* cercariae failed in this laboratory, thus confirming the taxonomic relationship and second intermediate host specificity of these two very closely related species.

The significance of the second intermediate host specificity demonstrated by microphallids as it might reflect phylogenetic relationships is not clear. A case in point is *Microphallus claviformis* Brandes, 1888 (Syn. *M. limuli* Stunkard, 1951). Deblock and Rosé (1965) discovered the metacercariae of *M. claviformis* in an isopod, *Sphoeroma serratum,* following the invalidation of *M. limuli* by Biguet, Deblock and Capron (1958). Stunkard (1951, 1960) recognized the close resemblance of the excysted metacercariae of *M. limuli* and *M. claviformis,* but because the former were in the chelicerate, horse-shoe crab, *Limulus polyphemus,* which is quite unrelated to the typical arthropod second intermediate host, he was reluctant to regard it a synonym.

The manner in which microphallid cercariae enter the crustacean second intermediate host was first described by Cable and Hunninen (1940). This description is not unlike that observed for *C. choanophallus* in shrimp with one interesting addition. Within 48 hr of penetration and passage into the hemocoel, the *C. choanophallus* cercariae have secreted thin protective mem-

branes which completely surround them, and within which they were seen to continue to migrate toward the shrimp abdominal musculature. The early presence of this membrane suggests that it may serve to protect the cercariae from host antibodies. The presence of the cercariae and encysted metacercariae in the shrimp muscle apparently elicited no significant reaction as shrimp were not refractory to superinfection upon challenge to reinfection. The functions of the cyst wall and the methods by which nutrition and excretion across the wall are accomplished are not well understood at this time, but in view of the energy requirements of the developing larva would form the basis for an exciting study.

Hunter and Vernberg (1953) and Ching (1962 a, b) demonstrated stages in the development and growth of microphallid metacercariae in the second intermediate host. This remarkable growth period in the life-cycle of *C. choanophallus* reached the stage of infectivity to mice when the vitelline glands appeared on about day 30 at 27 C in shrimp. The criteria for infectivity of the definitive host are not known. In this study, the muscular organs: the two oral suckers, the pharynx and the male papilla all appeared at the same time on about day 9. In general the staged development of *C. choanophallus* in shrimp is similar to that described previously for other microphallids.

The necessity of approaching a trematode life history study from the ecological point of view is mentioned in Cable and Hunninen's (1940) elucidation of the life history of *Spelotrema nicolli* as the key to finding the snail which shed cercariae. This was likewise true in the search for the cercaria of *C. choanophallus,* for it was not until a geographical survey led the way to marshes and ponds at the mouth of the Mississippi River where heavy infections of shrimp were found that snails bearing *C. choanophallus* cercariae were discovered. The question as to how shrimp taken from the Mississippi River at Greenville, Mississippi 540 miles from the mouth of the river became infected deserves some comment. It would not be possible for shrimp to migrate such a distance up-stream especially since young 20- to 25-mm shrimp were found infected. Infection must have occurred locally, but since infected snails were never found except at the mouth of the river, one may speculate that another yet-to-be-found snail is responsible, or that since shrimp infections are markedly lower in the regions up-river, the incidence in the snails is correspondingly so low as to make capturing an infected one unlikely. Since the Mississippi River rises and falls in water level several times a year, flooding into and communication with ponds and marshes along the banks, it is reasonable to assume that certain of these ponds not yet visited by this investigator could support populations of snails infected with *C. choanophallus* cercariae.

Rankin (1940) reported that *Gynaecotyla nassicola,* adults of which are harbored by migratory birds, showed a seasonal fluctuation in the snail *Nasa obsoleta,* the highest incidence being in the spring. No report was made on the incidence of infection for the second intermediate host. Studies on the life histories of *Maritrema obstipum* and *Levinseniella amnicolae* by Etges (1953) indicated that the highest incidence in the first intermediate host snail, *Amnicola pilsbryi,* and the second intermediate host, *Asellus communis,* infections were in the late summer and fall. Etges (1953) indicated that the periodicity of these infections was due to the migratory habits of birds which serve as the definitive hosts. In experiments with *C. choanophallus,* time has not permitted an extended survey of the incidence of infection in the first intermediate host, the unspined form of *Lyrodes parvula.* Present collections throughout the winter showed an incidence of 1 to 7 per cent suggesting that these snails may be continuously shedding cercariae whenever conditions permit. Since this study demonstrated that infected shrimp are found throughout the year, the definitive hosts (raccoon and rat) may maintain continuous short-term infections seeding snails at all seasons of the year in the subtropical New Orleans, Louisiana area. It may be that the short-term infections of the definitive host in microphallids serves no other purpose than to disperse the eggs. Sogandares-Bernal and Lumsden (1964) suggested that in short-term infections of *Ascocotyle leighi* Burton, 1956, which encysts in the hearts of certain poeciliid and cyprinodont fishes,

and in microphallids, ovigerous worms may be passed in natural infections, much in the same way the gravid proglottids of certain cestodes are passed from the definitive host. They pointed out that the short-term infection of the definitive host is probably the result of an evolutionary sequence which has allowed for the worms to continue with their biological function of reproduction without harming the host. The usual long-term infection with these parasites could lead to the death of the definitive host if the minute eggs were to enter the circulatory system with resultant complications (Africa, Garcia and de Leon, 1935a, b, 1936, 1937).

The 15-month study of *M. ohione* infected with *C. choanophallus* demonstrated two seasonal upsurges in incidence and intensity of infection with the heaviest infection occurring in the late summer and early fall. These two upsurges in *M. ohione* infection were seen to follow two periods of recruitment of young shrimp into the samples suggesting that the infection in *M. ohione* occurred mainly in young shrimp twice a season. The fact that juvenile shrimp in endemic areas are usually found in shallow still water containing vegetation upon which the unspined form of *Lyrodes parvula* is normally found substantiates this point of view. This does not rule out the possibility that infection of older shrimp, which are found in deeper swift moving water may take place continuously at a low level throughout the year with activity declining during the cold winter months.

Acknowledgments

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ETHEOSTOMA COLLETTEI, A NEW DARTER OF THE SUBGENUS *OLIGOCEPHALUS* FROM LOUISIANA AND ARKANSAS[1]

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ABSTRACT

Etheostoma (*Oligocephalus*) **collettei** is described from 308 specimens from the Ouachita River drainage in Louisiana and Arkansas and the Little, Red and Sabine river drainages of Louisiana. *Etheostoma collettei* appears to be most closely related to *E. asprigene* from which it is differentiated primarily by color pattern.

A new species of the subgenus *Oligocephalus*, herein described, is well represented in collections from Louisiana and Arkansas, but has previously been confused with *E. asprigene* (Forbes). John D. Black and Carl L. Hubbs, in their studies of Arkansas fishes during the early 1940's, recognized this undescribed form and regarded it as a subspecies of *E. asprigene*.

The new species is known from the Ouachita River in Louisiana and Arkansas and from the Little, Red and Sabine river drainages of Louisiana. It probably occurs in the Calcasieu River drainage, but no collections from this drainage have been examined.

We gratefully acknowledge the assistance of the following: Neil H. Douglas, Northeast Louisiana State College (NLSC), who provided specimens, Kodachrome transparencies and habitat notes on the type-locality; Bruce B. Collette, Bureau of Commercial Fisheries Systematics Laboratory, offered valuable suggestions and reviewed the manuscript; W. Ralph Taylor, U. S. National Museum (USNM), provided field data; Neil Hotchkiss, Patuxent Wildlife Research Center, identified aquatic plants; Ernest A. Lachner, United States National Museum (USNM), Edward C. Raney, Cornell University (CU), Reeve M. Bailey, University of Michigan Museum of Zoology (UMMZ), Ralph W. Yerger, Florida State University (FSU), and Frank Cross, University of Kansas (UK) kindly loaned specimens; C. Richard Robins, Institute of Marine Sciences, University of Miami, Royal D. Suttkus, Tulane University (TU) and William J. Richards, Bureau of Commercial Fisheries Tropical Atlantic Biological Laboratory, reviewed the manuscript.

Measurements and counts were made following Hubbs and Lagler (1958:8–15) except where otherwise indicated.

It is our pleasure to name this new darter for Bruce B. Collette, Bureau of Commercial Fisheries Systematics Laboratory, in recognition of his contributions to our knowledge of percid fishes.

Etheostoma (*Oligocephalus*) **collettei**, new species

Creole Darter
(Fig. 1)

Material. The description is based on 308 specimens from Louisiana and Arkansas. Holotype, USNM 201515 (♂ 56.3 milli-

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meters in standard length), Dugdemona River (Little River drainage), T15N, R3W, Section 6, Jackson Parish, La., 12 December 1966, Neil H. Douglas and Jacob P. Yelverton. Paratopotypes, USNM 201516 (38, 29.9-58.1).

Lower Ouachita River paratypes: NLSC 6317 (20, 29.9-52.9), Choudrant Bayou at La. Hwy. 15 bridge, Ouachita Parish, La., 29 September 1966, Douglas, K. Burnside, and H. Stegall; Univ. Ala. 2575 (17, 28.8-33.7), same data as NLSC 6317; CU 52108 (7, 40.8-61.5), Meridian Cr. on La. Hwy. 348, 1 mi. E. of Conway, Union Parish, La., T22N, R1W, Section 17, 12 November 1966, Douglas, Burnside and Yelverton; Tulane Univ. uncat. (10, 41.7-51.3), same data as CU 52108 (specimens apparently lost in transit); FSU 14678 (7, 40.5-60.0), Meridian Cr., T22N, R1E, Section 21, Union Parish, La., 15 June 1965, Douglas; USNM 172913 (14, 23.6-53.8), Meridian Cr., 1 mi. E of Conway, T22N, R1E, Section 17, Union Parish, La., 22 June 1965, Taylor; USNM 201517 (2, 51.9-52.1), Corney Lake Spillway, Claiborne Parish, La., W. Harman and H. Hobbs; USNM 172538 (4, 40.1-54.6), Little Corney Bayou at La. Hwy. 15, T22N, R3W, Section 1, Union Parish, La., Taylor; TU 52876 (5, 44.9-54.8), Meridian Cr., 1 mi. E of Conway, T22N, R1E, Section 17, Union Parish, La., 21 May 1956, Taylor and Lowe.

Upper Ouachita River paratypes: CU 42248 (71, 26.7-49.2), Middle Fork, Saline R. about 6 mi. W of Crows, Saline Co., Ark., 27 April 1962, Knapp and R. V. Miller; USNM 165915 (52, 25.5-48.5), South Fork, Saline R., 7.7 mi. SSW of Owensville, Garland Co., Ark., 22 April 1952, Lachner et al.; UMMZ 123229 (2, 30.0-31.9), Gulpha Cr. at jct. with Lake Hamilton, 10 mi. E of Hot Springs, Garland Co., Ark., 19 June 1938, J. and R. Black; USNM 165953 (9, 36.6-42.9), Antoine Cr., Trib. of Little Missouri R., 2.5 mi. N of Kirby, Pike Co., Ark., 21 April 1952, Lachner et al.

Little River paratypes: FSU 14676 (23, 35.3-45.6), Little Cr., T5N, R1E, Section 28, Rapides Parish, La., 21 June 1965, Douglas.

Red River paratypes: UMMZ 113734 (20, 36.9-50.6), ½ mi. S of Dry Prong, Grant Parish, La., 29 May 1932, Creaser, Hedrick and Amell.

Sabine River paratypes: FSU 14677 (8, 36.0-47.5), Sandy Cr. on La. Hwy. 11, T2N, R11W, Section 20, Vernon Parish, La., 24 June 1965, Douglas.

Comparisons with *Etheostoma asprigene* were based primarily on the following material from the Ouachita River drainage: USNM 173058 (20, 28.2-35.6); USNM 172482 (4, 19.2-25.7); USNM 172759 (2, 48.3-49.5); USNM 172571 (1, 55.2); USNM 172296 (16, 32.1-43.4); UK 3527 (1, 35.5); UMMZ 169795 (3, 34.3-41.9).

Diagnosis. Distinguished from other members of the subgenus *Oligocephalus* by a combination of the following characters: dorsum with 3 or 4 prominent, dark blotches and 4 or 5 less conspicuous blotches; usually a prepectoral dark blotch; humeral spot pronounced; a dusky bar on body beneath pectoral fin; darkly pigmented scale centers contribute to the formation of horizontal lines on the body that tend to disappear ventrally about 4-5 scale rows below the lateral line; anal spines 2; belly scale edges thickened as tubercles in a few male specimens; prepectoral area and breast naked; cheeks, opercles, nape and belly with scales; eye ovoid and breaks the dorsal outline in profile; branchiostegal membranes slightly joined to overlapping; lateral line nearly straight and incomplete (Table 2), 28-46 (usually 32-42) pored scales, 3-21 (usually 8-18) unpored scales, 44-60 (usually 47-52) total scales; pectoral fin rays modally 13; coronal pore single; infraorbital canal complete, with 8 pores; preoperculomandibular canal with 10 pores; supratemporal canal usually complete in adults; snout blunt, slightly decurved; urogenital papilla moderately long in spawning females.

Description. Etheostoma collettei is a large, robust species of *Oligocephalus* (Fig. 1). The largest specimen examined is a male 61.5 mm SL. Table 1 gives the proportional measurements for the holotype and nine paratopotypes.

A moderately developed nuchal hump is present in both sexes, slightly more pronounced in males larger than 40 mm SL; the body is deepest at origin of spinous dorsal; the rostral frenum is well developed.

The body, including nape and belly, is completely covered with scales in most specimens; however, in some (including holotype) the scales of anterior ¼ to ½ of belly

are partially to entirely embedded. The nape is nearly naked to fully covered with embedded scales; breast and prepectoral areas are naked (latter with a few embedded scales in large individuals); the opercle is fully invested with large, wholly to partially exposed scales; approximately 50 per cent of the cheek below and behind eye with small, partially exposed scales.

Scales below lateral line 7-12 (usually 8-10); transverse scale rows 11-16 (usually 13-15); scales around caudal peduncle 18-24 (usually 19-22).

Vertebrae in 27 individuals from type-series: 36 (10 including the holotype), 37(15), 38(2). Palatine and vomerine teeth present.

Dorsal spines number 8-12 (usually 10-11); dorsal soft rays 11-14 (usually 12-13); anal fin with two spines and 6-8 (usually 7) soft rays. Pectoral rays (left side only) 11-14 (usually 12-14).

The shape of the spinous dorsal is variable but it is usually low and little rounded; the soft dorsal is somewhat larger than the anal fin, especially in large specimens; the posterior edge of the caudal fin is truncate.

Coloration of males. Color descriptions are based on observations made by Knapp and on two Kodachrome transparencies provided by Neil H. Douglas of a specimen approximately 55 mm SL, collected 29 June 1966, from Flem Branch (Little River drainage), Grant Parish, La., and a specimen about 65 mm SL taken 15 October 1966, from Choudrant Cr. (Ouachita River drainage), Ouachita Parish, La.

The 8-9 bluish-brown blotches on the dorsum are a distinctive feature of the color pattern. The second, fifth, seventh, and eighth are often more pronounced than the others. The location and relative prominence of the blotches are as follows: 1—nape just behind the head, often faint or absent; 2—nape just anterior to the spinous dorsal fin, pronounced; 3 and 4—below the spinous dorsal, faint; 5—below the posterior end of the spinous dorsal, pronounced; 6—below

←

Figure 1. *Ethcostoma collettei*, new species. Drawn from the holotype, USNM 201515, a male, 56.3 mm in standard length, collected in the Dugdemona River, Little River drainage, Jackson Parish, Louisiana.

Table 1
Proportional measurements of *Etheostoma collettei*, expressed in hundredths of standard length.

Character	USNM 201515 Holotype (♂)	USNM 201516 Paratypes 4 ♂♂ Range	4 ♂♂ Mean[1]	5 ♀♀ Range	5 ♀♀ Mean
Standard length (mm)	56.3	46.8–53.1	51.1	41.5–58.1	49.1
Predorsal length	35	35–36	35.4	34–36	35.2
Body depth	23	18–20	20.0	18–21	19.4
Caudal peduncle length	19	17–19	18.4	16–18	17.4
Caudal peduncle depth	10	9–10	9.4	9–10	9.2
Head length	30	29–30	29.8	28–30	29.2
Head depth at orbit	12	12–13	12.2	11–13	12.4
Orbit width (vertical)	6	6	6.0	5–6	5.6
Orbit width (horizontal)	7	6–7	6.8	7	7.0
Snout length	6	6–7	6.4	6–7	6.4
Upper jaw length	8	8–9	8.2	8–9	8.4
Width of gape	9	7–9	8.6	7–8	7.8
Spinous dorsal base	30	27–31	29.4	28–31	28.8
Soft dorsal base	20	19–21	19.6	18–20	19.4
Anal base	14	12–14	13.0	10–13	11.6
Longest dorsal spine	12	11–13	12.0	11–13	11.6
Longest dorsal soft ray	16	13–16	14.8	13–15	14.4
Longest anal ray	15	14–16	15.0	14–15	14.8
First anal spine	9	9–12	9.6	7–9	8.0
Caudal fin length	18	18–20	18.6	18–20	18.8
Pectoral fin length	24	22–24	23.0	22–24	23.4
Pelvic fin length	20	17–20	18.8	18–20	18.8
Interpelvic distance	2	2	2.0	2	2.0
Transpelvic distance	8	8	8.0	7–9	8.0

[1] Holotype included in mean for males.

the origin of the soft dorsal, faint; 7—below the mid soft dorsal, pronounced in some specimens but faint in others; 8—just behind the soft dorsal, pronounced; 9—midway the dorsal surface of the caudal peduncle, faint and sometimes absent.

Most specimens have 5-8 vague, vertical bars on the posterior half of the body. These bars have a bluish cast in life but appear brown in preserved specimens. The area between the bars, the ventral surface of the caudal peduncle, and the belly are bright orange. The belly of most preserved male specimens is dusky.

A poorly-defined, brown, basicaudal blotch is discontinuous with a small distinctive spot lying just below the dorsal procurrent rays of the caudal fin. A similar spot is present above the ventral procurrent rays of the caudal fin in small specimens but apparently is obscured in larger specimens by being joined to the larger caudal blotch. Posterior to the caudal blotch at the base of the caudal rays, two roundish, orange spots lie just above and below the center of the caudal base.

The axil of the pectoral fin is densely pigmented with melanophores but characteristically has a bright orange bar. Posterior to the pectoral axis, a darkened bar of small melanophores begins immediately below the lateral line and extends ventrad to just behind the pelvic base. This bar is variable, but it is evident in most specimens. The breast of adult males is often covered with micromelanophores; however, some large adult males have few melanophores on the breast and in several specimens the breast is immaculate. The Choudrant Creek specimen in the Kodachrome transparency has a tinge of orange on the breast.

The prepectoral area, tinged with orange in life, often has a dark blotch. Pigmentation of the urogenital papilla varies, but usually a few lateral melanophores are present.

On the head there is a dark, well-defined subocular bar and a short, broad, postocular

TABLE 2
Lateral-line scale counts in *Etheostoma collettei* and *E. asprigene*

Species and Drainage	Total Lateral Line Scales																		N	$\bar{x}$
	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58–60					
E. collettei																				
Upper Ouachita R.			3	2	6	13	14	22	16	11	7	8	1	1	1	1			106	51.3
Lower Ouachita R.	1	1	6	12	14	11	7	11	4	3	–	2							72	49.0
Little R.			1	5	7	9	13*	8	6	5	4	4							62	50.5
Red R.					2	2	3	3	3	3	2	1	–	1					20	51.6
Sabine R.						1	4	1	2										8	50.5
E. asprigene																				
Ouachita R.	2	1	1	3	7	10	8	8	1	2	1								44	49.2

Lateral-line scale counts in *Etheostoma collettei* and *E. asprigene*

Species and Drainage	Pored Lateral Line Scales																		N	$\bar{x}$
	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	
E. collettei																				
Upper Ouachita R.	2	3	2	2	10	10	12	10	20	14	7	8	5	2						107	35.2
Lower Ouachita R.				2	–	3	1	5	8	18	4	8	8	6	4	1	4			72	38.1
Little R.						1	2	7	8	6	10	3	10	6	5*	1	2	1		62	38.5
Red R.						1	–	–	2	3	2	6	2	2	–	–	–	–	2	20	39.0
Sabine R.		1	–	–	–	–	1	–	–	4	–	1	–	–	–	1				8	36.6
E. asprigene																				
Ouachita R.				1	–	–	4	2	4	7	3	6	3	5	2	2				39	38.0

Lateral-line scale counts in *Etheostoma collettei* and *E. asprigene*

Species and Drainage	Unpored Lateral Line Scales																			N	$\bar{x}$
	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21		
E. collettei																					
Upper Ouachita R.[1]									3	2	11	13	23	13	14	9	9	5	1	103	16.0
Lower Ouachita R.	1	–	–	2	5	7	10	4	12	9	10	6	4	1	1					72	10.9
Little R.						5*	3	10	11	10	5	11	5	2						62	11.8
Red R.						2	–	–	2	4	5	4	3							20	12.6
Sabine R.					1	–	–	–	1	1	1	–	2	–	1	–	–	–	1	8	13.9
E. asprigene																					
Ouachita R.					1	4	5	6	5	10	2	4	–	–	1	–	1			39	11.2

[1] Includes one specimen with 31 unpored scales.
* Includes count for holotype.

blotch which does not extend to the preopercular margin. A diffuse, dark stripe from the anterior edge of the orbit to the upper lip gives the effect, when viewed from above, of a pale stripe through the frenum. A small dark spot on the dorsal part of the orbit extends onto the eye. A thin line of concentrated melanophores is present along the mandibular and maxillary grooves. The opercle is darkly pigmented as is the posterior edge of the preopercle. The branchiostegal membranes are also heavily pigmented and tinged with red-orange where they overlie the prepectoral area. The humeral spot is dark and well defined but is not enlarged.

The spinous dorsal fin membrane has a narrow, dark, marginal band which appears to have a greenish-blue cast. Beneath the distal band is a broad, vivid, red-orange band followed by a narrower dark band. Along the base of the spinous dorsal fin is a very narrow, dusky-orange band. The pig-

Table 3
Comparison of *Etheostoma collettei* and *E. asprigene* from the Ouachita River drainage of Louisiana.

Character	*E. collettei*	*E. asprigene*
Blotches on dorsum	8–9, 4 pronounced	8–9, all equally developed
Eye shape	Ovoid	Round
Snout shape	Slightly decurved, blunt	Produced, acute
Body bars	5–7, indistinct above L. L.	6–8, distinct above L. L.
Postpectoral bar	Well-developed	Absent or faint
Spinous dorsal	Wide orange-red band, narrow medial dark band	Narrow orange-red band; wide medial dark band
Humeral spot	Pronounced	Absent or faint
Postocular stripe	Short, broad; not reaching operculum	Long, narrow; reaching operculum
Prepectoral area	Naked	Partially exposed ctenoid scales
Pectoral rays	11–14, modally 13	12–15, modally 14

mentation of all three bands is restricted to the membranous portion of the fin and does not go across the rays.

The soft dorsal membrane has a dark, distal band similar to that of the spinous dorsal. Beneath the distal band is a broad, red-orange band which is dissected by the dusky rays. The base of the soft dorsal is marked by one, sometimes two, poorly-defined dark bands. The anal fin is greenish-blue along its base. Preserved specimens usually show an even gradation from a dark base to a light distal margin. In large preserved specimens the entire anal fin is often dark. The caudal fin membrane has 5-7 poorly defined dusky bars and, in larger specimens, a dusky distal margin. The interradial membranes of the pelvic fins in large specimens are densely covered with micromelanophores. The anterior interradial membrane is tinged with orange and the proximal portion of the other membranes is bluish-green. The pectoral fin displays several poorly-defined bars which are often obscure or absent. In life the proximal half of the pectoral fin is tinged with orange.

Coloration of females. The following account is based on preserved specimens. In general, the females are similar to the males, but, they differ in several subtle pigmentary features. The body above the lateral line is usually mottled. The vertical bars are less well defined than in the male. There are few, if any, micromelanophores on the venter, making the pattern more highly contrasted than in the male. The urogenital papilla is immaculate. The mandibular groove is more heavily pigmented and the branchiostegal membranes somewhat less pigmented in the female than in the male. The membranes of the soft dorsal are marked by 5 or 6 narrow dark bands. The anal and pelvic fins have little or no dark pigment.

Habitat. Neil H. Douglas (pers. comm.) has kindly provided the following notes on the habitat at the type-locality in the Dugdemona River in Jackson Parish, La. "This area is near the headwaters of the river, where the depth is normally two inches to three feet, with a width of 10-20 feet. The shore line is heavily vegetated. The stream flows with moderate to fast current at this point, and many logs and cypress stumps create riffle areas. The bottom is of hard soil with no rocks or gravel." Douglas further stated that the habitat at the type-locality is common in north central Louisiana, and that he has collected *E. collettei* throughout this area in streams with moderately strong current.

In the Saline River of the upper Ouachita drainage, one of us (Knapp) has taken *E. collettei* in several habitats. Near Crows, Arkansas, it was taken from heavy growths of *Podostemum ceratophyllum* in rocky chutes along with *E. blennioides* Rafinesque and *E. zonale* (Cope). In other areas of the Saline River, it was taken from clear gravel riffles with *E. whipplii* (Girard).

Relationships. In some features *Etheostoma collettei* appears very similar to *E. asprigene;* however, a number of obvious differences exist (Table 3). Breeding tubercles, similar in type and arrangement to those described by Collette (1966:597) for

E. caeruleum Storer, have been found in a few males. The rather elongate urogenital papilla of the ripe female is quite unlike that of *E. asprigene* and may be an adaptation for deposition of eggs on aquatic vegetation. In view of these dissimilarities, we do not feel that *E. collettei* can be placed in the *E. asprigene* species group as visualized by Ramsey and Suttkus (1965:74), but believe that it is more closely related to the *asprigene* group than to other groups in *Oligocephalus*.

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March 24, 1969

MYSIDOPSIS BAHIA, A NEW SPECIES OF MYSID (CRUSTACEA:MYSIDACEA) FROM GALVESTON BAY, TEXAS[1]

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ABSTRACT

A new species of mysid, *Mysidopsis* **bahia**, is described from West Bay, Galveston, Texas. This mysid was found in three areas within the Galveston Bay system. The salinity at the collection sites varied from 18‰ to 29‰ and the temperature, from 24°C to 32°C. *M. bahia* differs from *M. almyra* and *M. bigelowi*, which also have been reported from the Gulf of Mexico, by the armature of the telson, the number of spines on the uropod together with an unsegmented antennal scale.

Specimens of a new species of mysid were collected during the week of November 22, 1965, near the northwest shore of Galveston Island in West Bay. A hand screen was used to collect them in water one-half meter deep, close to shore. The salinity was 28‰ and the temperature was 24°C. The following description is based on the laboratory-reared progeny of these specimens.

Mysidopsis **bahia,**[3] new species

Figures 1-18

Description. Length of adults from anterior margin of carapace to end of uropods, excluding setae, varies from 4.4 mm to 9.8 mm. Anterior margin of carapace roundly triangular, not produced into rostrum; posterior margin concave; somite 8 exposed in dorsal view. Eye rounded and slightly kidney shaped. Telson linguiform with bluntly rounded apex; lateral margins usually with 19-22 short spines on each side; apex with 4-5 pairs of closely set strong spines in adults; central pair longest, about ¼ as long as telson. Third segment of antenna 1 of male with lobe bearing thick fine setae. Scale of antenna 2 narrowly lanceolate composed of single segment which bears setae along entire length on each side. Labrum rounded anteriorly; posterior margin with small central indentation, middle portion with short setae. Molar of mandible reduced or absent; incisor of left mandible with 7 teeth, right with 6 teeth; left lacinia mobilis broad with 6 teeth; right lacinia smaller, constricted at base, with 7 teeth; medial row of closely set stout spines, 10-12; on left mandible this row ends with tuft of setae. Palp well developed. Outer plate of maxilla 1 with 8 spines at apex; inner plate with 2 setae at apex and 1 on outer margin. Proximal lobe of maxilla 2 with 4 setae on truncate apex; exopod usually bears 6-10 setae. Thoracic leg 1 (maxilliped) short, stout. Endopod of leg 2 slender, ending in spine. Endopod of male pleopod 4 with single lobe bearing 4 stout spines, 1 short spine, exopod longer than endopod with long apical spine. Exopod of uropod about twice as long as telson, curved gently outward; endopod about ¾ as long as exopod, armed on ventral surface with 2 to 3 spines near medial margin distal to statocyst.

Color. Living specimens usually transparent. However, color may be distributed over

[1] Based on a thesis submitted in partial fulfillment of the requirements for an M.S. degree, Texas A&M University, 1966.
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[3] From the Spanish *bahia*, bay.

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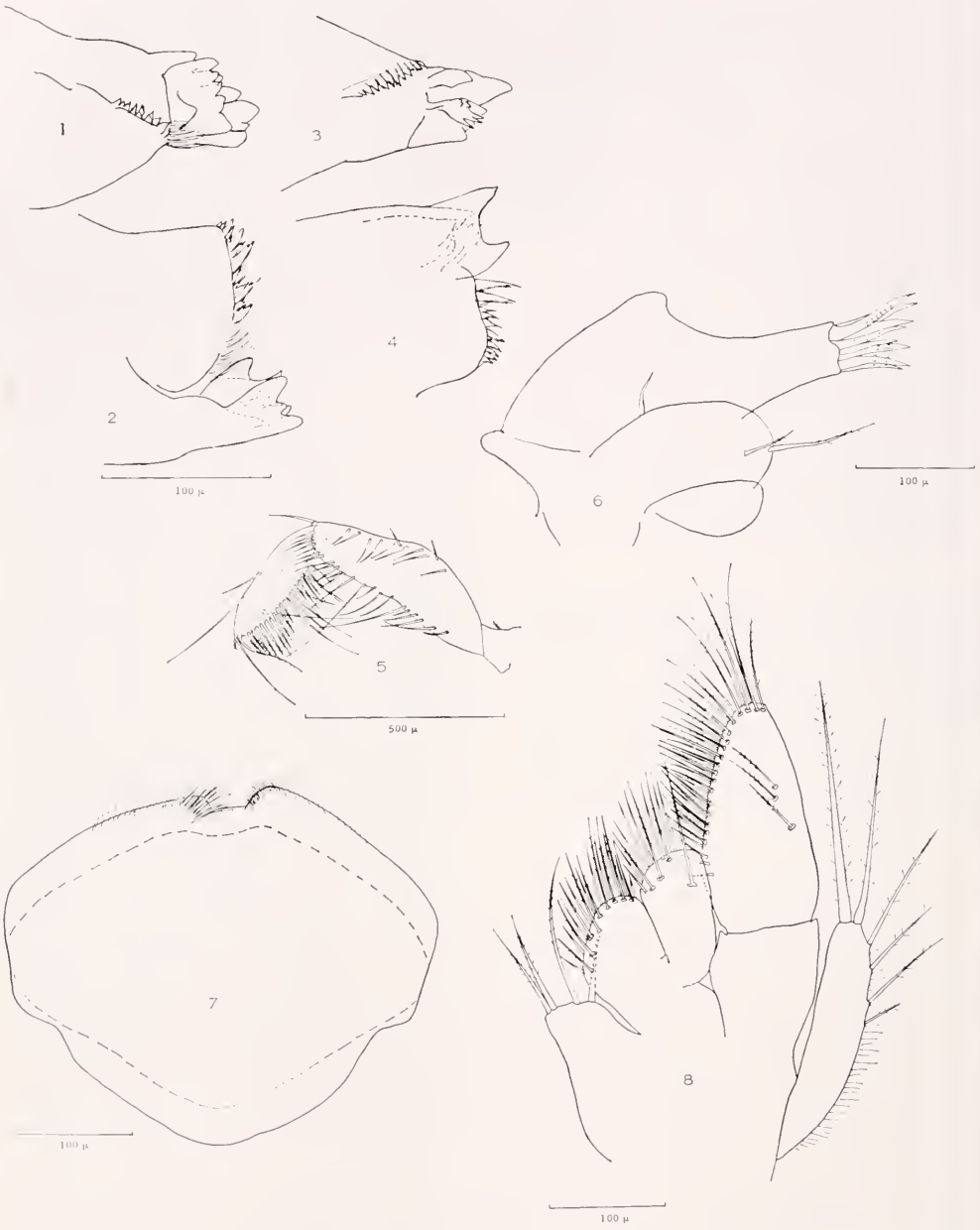
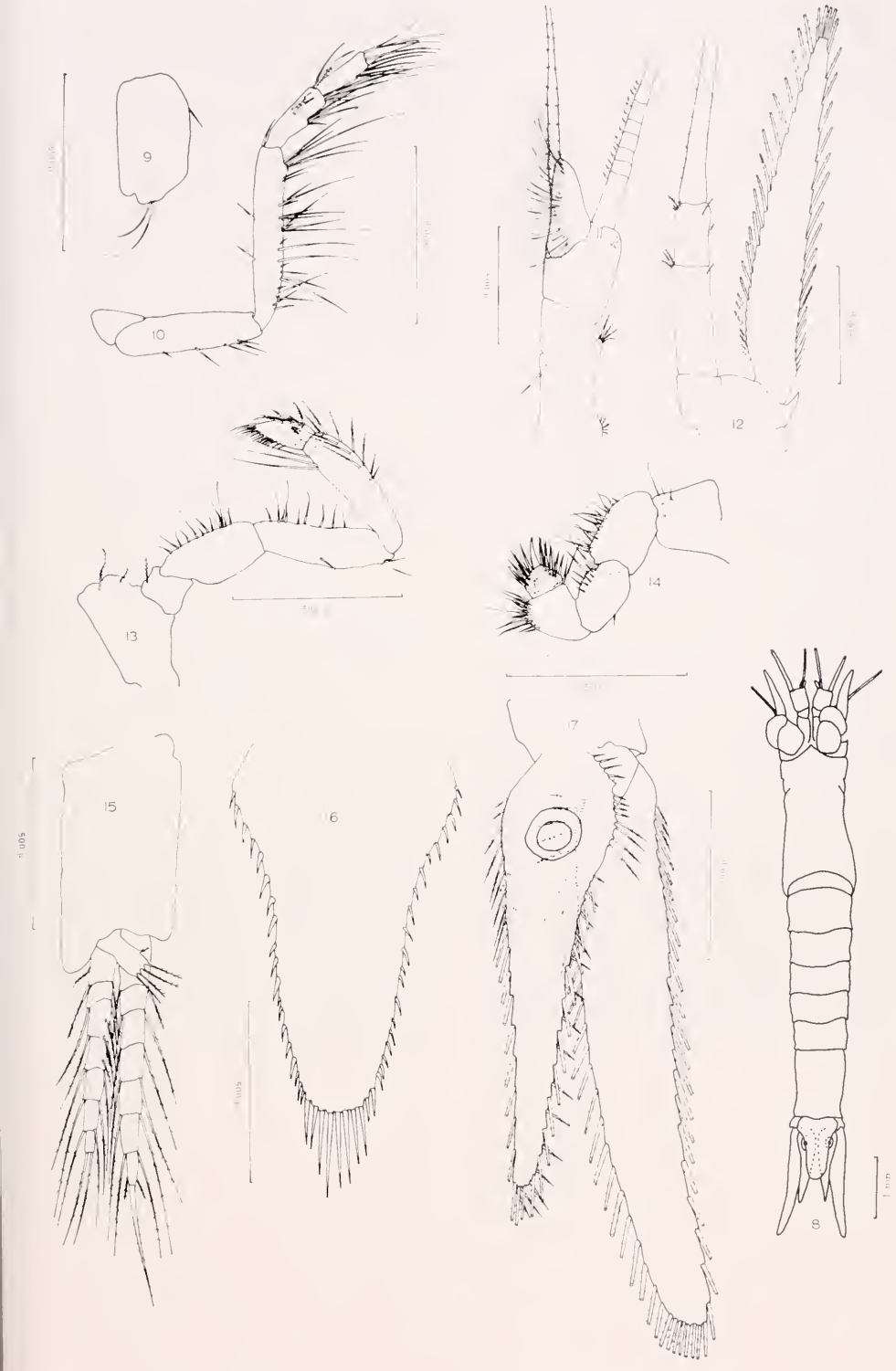


Figures 1-8. *Mysidopsis bahia*, new species. 1. Left mandible, gnathobasic process, oblique internal view. 2. Left mandible, gnathobasic process, internal view. 3. Right mandible, gnathobasic process, oblique internal view. 4. Right mandible, gnathobasic process, internal view. 5. Left mandibular palp. 6. Maxilla 1. 7. Labrum. 8. Maxilla 2.

→

Figures 9-18. *Mysidopsis bahia*, new species. 9. Genital appendage, male. 10. Thoracic leg 8. 11. Antenna 1, ventral, male. 12. Antenna 2. 13. Thoracic leg 2. 14. Thoracic leg 1. 15. Pleopod 4, male. 16. Telson. 17. Right uropod, dorsal. 18. Male, dorsal.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entire surface of animal in yellows, browns or blacks. Dorsally, preserved specimens have 2 contracted chromatophores at base of telson; ventrally, 1 pair at base of mouthparts, 2 pairs on thorax, 5 median chromatophores on abdomen.

Types. The male holotype, USNM 113832, is a specimen reared in the laboratory from those originally collected in November 1965. Fourteen similarly reared specimens are designated as paratypes, USNM 113834. Twenty-two field specimens are also designated as paratypes, USNM 113833.

Occurrence. This mysid has been found at several locations within the Galveston Bay system. My original collection site was West Bay. *Ruppia maritima* occurred in patches on a sand bottom. Using a hand screen I collected this mysid and postlarval *Penaeus, Tozeuma, Hippolyte* and *Palaemonetes.* Field paratypes were collected by Mr. Cornelius R. Mock in Lake Como, an inlet of West Bay. The specimens that I examined from this site were collected from July through September 1966. A net tow of 15 m along the bottom yielded hundreds of specimens of *M. bahia.* The bottom in Lake Como was sand, the salinity during this period varied between 22‰ and 29‰, and the temperature ranged from 24°C to 32°C. Additional specimens given to me by Dr. David V. Aldrich were collected in September 1964 from Clear Lake, which is a secondary bay opening into Galveston Bay. The salinity in Clear Lake was 18‰ and the temperature, 29°C at the time of collection. Mock (1966) reported this site (A) with a bottom consisting of a uniform mixture of sand, silt and clay.

Remarks. Two species of *Mysidopsis* have been reported from the Gulf of Mexico (Bowman, 1957, 1964; Clarke, 1956; Tattersall, 1926, 1951), *M. almyra* Bowman and *M. bigelowi* Tattersall. An unsegmented antennal scale serves to distinguish *M. bahia* and *M. bigelowi* from *M. almyra* which has a segmented antennal scale. *M. bahia* and *M. almyra* have a slender second leg while in *M. bigelowi* this leg is robust. The number of strong spines on the apex of the telson also differentiates these species; *M. bigelowi* has 3 pairs, *M. bahia,* 4-5 pairs, and *M. almyra,* 6-7 pairs. An additional distinguishing character is the number of spines on the endopod of the uropod; *M. almyra* has 1 spine, *M. bahia,* 2-3 spines and *M. bigelowi,* 5 spines.

Acknowledgments

I appreciate the advice and comments of Dr. Thomas E. Bowman upon my introduction to Mysidacea. Dr. William D. Clarke kindly discussed mysids with me and encouraged my interest in them.

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DIGENETIC TREMATODES OF MARINE TELEOST FISHES FROM BISCAYNE BAY, FLORIDA

ROBIN M. OVERSTREET
Institute of Marine Sciences, University of Miami, Miami, Florida

p. 119

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TULANE STUDIES IN ZOOLOGY AND BOTANY

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DIGENETIC TREMATODES OF MARINE TELEOST FISHES FROM BISCAYNE BAY, FLORIDA[1]

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Abstract

This study includes 111 species of Digenea from 69 of 113 species of teleost fishes examined from Biscayne Bay, Florida. Biscayne Bay represents the reported northern limit along the Atlantic coast for all but 22 of the 111 species. It represents the southern limit for only one, *Didymocystis scomberomori*. From the known collections reported in the literature, the Digenea from Biscayne Bay appear to consist primarily of a tropical fauna. Species previously known from the Pacific Ocean only are *Botulisaccus pisceus* and *Pseudocreadium scaphosomum*. There are 81 new host records.

Two new genera are created: *Claribulla* (Fellodistomatidae) and *Apertile* (Opecoelidae). Thirteen new species are described: *Apocreadium cryptum, Cadenatella floridae, Claribulla longula, Diphtherostomum albulae, Hamacreadium confusum, Hurleytrema pyriforme, Hymenocotta manteri, Lasiotocus albulae, Lasiotocus haemuli, Lasiotocus mugilis, Neolepidapedon macrum, Nicolla halichoeri*, and *Opegaster pritchardae*.

Eleven new combinations are made: *Apertile holocentri*, formerly *Neopecoelus holocentri* Manter, 1947; *Apocreadium foliatum*, formerly *Homalometron foliatum* Siddiqi and Cable, 1960; *Bianium longipygum*, formerly *Diploproctodaeum longipygum* Oshmarin, Mamaev, and Parukhin, 1961; *Bianium macracetabulum*, formerly *Diploproctodaeum macracetabulum* Oshmarin, Mamaev, and Parukhin, 1961; *Diplomonorchis magnacetabulum*, formerly *Diplomonorcheides magnacetabulum* Thomas, 1959; *Helicometrina execta*, formerly *Helicometra execta* Linton, 1910; *Hurleytrema malabonensis*, formerly *Pseudohurleytrema malabonensis* (Velasquez, 1961); *Hurleytrema shorti*, formerly *Pseudohurleytrema shorti* Nahhas and Powell, 1965; *Megasolena hysterospina*, formerly *Lepidauchen hysterospina* Manter, 1931; *Myosaccium opisthonemae*, formerly *Neogenolinea opisthonemae* Siddiqi and Cable, 1960; and *Pseudopecoelus scorpaenae*, formerly *Neopecoelus scorpaenae* Manter, 1947.

Five genera have been synonymized: *Bilecithaster* Siddiqi and Cable, 1960, synonym of *Diplangus* Linton, 1910; *Diplomonorcheides* Thomas, 1959, synonym of *Diplomonorchis* Hopkins, 1941; *Neogenolinea* Siddiqi and Cable, 1960, synonym of *Myosaccium* Montgomery, 1957; *Neopecoelus* Manter, 1947, synonym of *Pseudopecoelus* Von Wicklen, 1946; and *Parahurleytrema* Nahhas and Powell, 1965, synonym of *Hurleytrema* Srivastava, 1938.

Twelve species have been synonymized: *Antorchis holacanthi* Siddiqi and Cable, 1960, synonym of *Antorchis urna* (Linton, 1910) Linton, 1911; *Bilecithaster ovalis* Siddiqi and Cable, 1960, synonym of *Diplangus parvus* Manter, 1947; *Diplomonorchis micropogoni* Nahhas and Cable, 1964, synonym of *Diplomonorchis leiostomi* Hopkins, 1941; *Helicometra pretiosa* Bravo-Hollis and Manter, 1957, a synonym of *Helicometra torta* Linton, 1910; *Helicometrina parva* Manter, 1933, and *Helicometrina trachinoti* Siddiqi and Cable, 1960, synonyms of *Helicometrina execta* (Linton, 1910); *Hexangitrema breviceca* Siddiqi and Cable, 1960, synonym of *Hexangitrema pomacanthi* Price, 1937; *Manteria costalimai* Freitas and Kohn, 1964, synonym of *Manteria brachydera* (Manter, 1940); *Megasolena archosargi* Sogandares-Bernal and Hutton, 1959, synonym of *Megasolena hysterospina* (Manter, 1931); *Opisthadena cortesi* Bravo-Hollis, 1966, synonym of *Opisthadena dimidia* Linton, 1910; *Paracryptogonimus neoamericanus* Siddiqi and Cable, 1960, synonym of *Paracryptogonimus americanus* Manter, 1940; and *Pseudohurleytrema ottoi* Travassos, Freitas, and Bührnheim, 1965, synonym of *Hurleytrema shorti* (Nahhas and Powell, 1965).

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I am especially indebted to Dr. Harold W. Manter and Mrs. Mary Hanson Pritchard of the University of Nebraska for verifying my identifications, answering many questions, and permitting me to use their library and collections of trematodes for four days. I wish to thank Drs. Edwin S. Iversen, Frederick M. Bayer, W. Henry Leigh, C. Richard Robins, and Carl J. Sindermann, all of the University of Miami, for their suggestions and criticisms of the manuscript. Space and equipment were provided by Dr. Leonard J. Greenfield. I also wish to thank those who helped collect fishes for this study, especially Dr. Ronald Smith, Mr. Thomas Fraser, and Mr. Lucky McLeod. Identifications or verifications of my identifications of the hosts were willingly made or obtained by Dr. C. Richard Robins, Mr. Thomas Fraser, Dr. Alan R. Emery, and Dr. Martin Roessler. I am grateful to those persons who lent or gave me specimens of Digenea; those people are acknowledged in the text under the appropriate sectfons.

Introduction

The present study was undertaken to make the digenetic trematode fauna of fishes from the east coast of Florida better known. Emphasis has been placed on several of the numerous fishes that spend either all or a portion of their lives in Biscayne Bay.

This report concerns 111 species of adult Digenea collected from 69 of 113 species

of teleosts represented by 333 individuals. A few of these trematodes have been reported from the Atlantic coast of Florida by Ward (1954), Schroeder (in press), Anderson (1965), Daigger and Lewis (1967), and Overstreet (1968). Descriptions of most of the previously named species are available in the literature based on collections from Beaufort, North Carolina (Linton, 1905; Manter, 1931; Pearse, 1949); Dry Tortugas, Florida (Linton, 1910; Manter, 1933a, 1933b, 1934, 1947); Woods Hole Region, Massachusetts (Linton, 1900, 1901, 1940); Bermuda (Linton, 1907; Hanson, 1950); Bahama Islands (Sparks, 1957; Sogandares-Bernal, 1959); Curaçao and Jamaica (Nahhas and Cable, 1964); Puerto Rico (Price, 1934; Siddiqi and Cable, 1960); Cuba (Pérez Vigueras, 1955a, 1955b, 1955c, 1957, 1958); and different areas of the Gulf of Mexico, including the west coast of Florida (Sparks, 1958; Sogandares-Bernal and Hutton, 1959a, 1959b, 1959c; Nahhas and Short, 1965; Nahhas and Powell, 1965). Other known species encountered in this study have been reported from other localities and are discussed in the text when relevant.

Methods

Fishes for study were collected between January 1966 and May 1968 by hook and line, seine, trap, trawl, or spear and kept alive until they could be examined. Almost all the fishes were examined within two days after capture. Examination included the entire alimentary system and coelomic cavity of all fishes, and the gills, heart, swim bladder, urinary bladder, and other tissues of many. Most trematodes were washed in 0.8 per cent saline; fixed in hot alcohol-formalin-acetic acid (AFA), using light coverslip pressure when necessary to prevent curling; stained with Van Cleave's hematoxylin; and mounted in Permount. Lithium carbonate and butyl amine were added during dehydration in 80 per cent alcohol to prevent future fading. Sectioned material was stained with Mallory's trichrome stain or Harris's hematoxylin with eosin as a counterstain. Measurements and computed ratios were taken using microns as the unit, but the values were rounded off for the text. All measurements are in millimeters unless otherwise indicated. Measurements were taken on fully-formed eggs unless the text indicates otherwise. The diameter of the oral sucker was compared with that of the acetabulum, with the oral sucker representing one, in order to compute the sucker ratio. Asterisks indicate new host records. The common names, authors, and families of the fishes examined are included in the Host-Parasite List following the discussion. A camera lucida was used for all illustrations. Holotypes have been deposited in the Helminthological Collection of the United States National Museum, and the hosts in the Ichthyological Collection of the Institute of Marine Sciences, University of Miami, Miami, Florida.

Description and Discussion of Species

Except for new species, the discussion is limited to aspects that supplement the available literature. A partial synonymy is presented.

FAMILY SANGUINICOLIDAE Graff, 1907

Deontacylix ovalis Linton, 1910

Host: *Kyphosus sectatrix* (6 of 6).
Site: Body cavity.

Discussion: Land (1967) considered the family Aporocotylidae Odhner, 1912, in which *Deontacylix ovalis* had previously been placed, as a synonym of Sanguinicolidae. My specimens agree with the original description by Linton (1910:83-84) and extended by Manter (1947:367-368). The testis is usually not as distinct as described by Manter, but is more reticulate with short lateral bulges extending from the longitudinal extracaecal extensions. Adjacent lateral bulges often overlap or touch each other. The lobed ovary occasionally has numerous perforations. The excretory system includes a very short, terminal, sac-like vesicle with branched collecting ducts that extend anteriorly, accompanying the lateral nerves. The excretory pore is terminal.

FAMILY BUCEPHALIDAE Poche, 1907

Bucephalus scorpaenae Manter, 1940

Figure 1

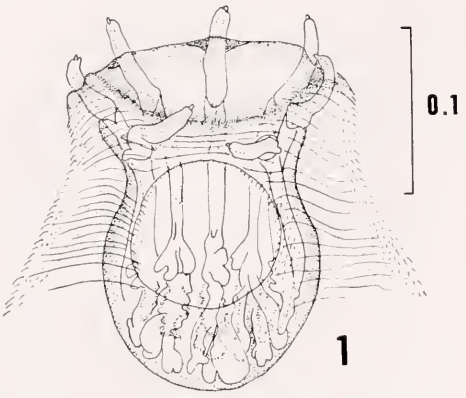


Figure 1. *Bucephalus scorpaenae,* ventral view.

Hosts: *Scorpaena grandicornis* (2 of 2)*; *Scorpaena plumieri* (2 of 4).
Site: Pyloric caeca and intestine.

Discussion: Figure 1 shows at the base of rhynchus previously undescribed gland cells with large ducts which join the bases of the tentacles. Manter (1940c:5) and Winter (1960:183) described the dorsal wall of the anterior sucker as being vesicular and probably glandular. Other species of bucephalids, some without papillae or tentacles, have been reported to possess anterior gland cells. Hopkins (1954:356, figs. 1-2; 358, 6-7) described and illustrated such cells in *Rhipidocotyle transversale* Chandler, 1935, and *Bucephaloides strongylurae* Hopkins, 1954, as extending over and around the rhynchus, and subsequently opening anteriorly.

Bucephalus varicus Manter, 1940

Bucephalus polymorphus Baer, 1827, of Nagaty, 1937, and others.

Bucephalus pseudovaricus Velasquez, 1959.

Hosts: *Caranx crysos* (1 of 2); *Caranx hippos* (3 of 3).
Site: Pyloric caeca, few in stomach.

Discussion: Manter (1963c:228) discussed the synonymy and identification of this variable species. The present specimens show further variability in that the testes are usually separated by the proximal portion of the uterus.

Prosorhynchus pacificus Manter, 1940
Gasterostomum sp. Linton, 1910 (from *Mycteroperca bonaci* and *M. venenosa*).
Prosorhynchus atlanticus Manter, 1940.

Hosts: *Mycteroperca bonaci* (3 of 3); *Mycteroperca microlepis* (2 of 2).
Site: Intestine and pyloric caeca.

Discussion: Hanson (1950:75) considered *Prosorhynchus atlanticus,* apparently from a misidentified host, as a synonym of *P. pacificus* on the basis of the variability in the specimens she examined from Bermuda. She noted a wide range in the size of eggs. Nahhas and Cable (1964:174) reported nonintergrading egg lengths in specimens from Curaçao, Jamaica, and Puerto Rico, as I find in my specimens, and they did not accept the synonymy. Winter (1960:187-189), however, reported specimens from Mazatlán, Sinaloa, Mexico, with eggs 29 to 33 by 19 to 20 microns, about the same measurements as found in most Atlantic specimens. I am therefore accepting the synonymy.

Rhipidocotyle adbaculum Manter, 1940

Hosts: *Scomberomorus maculatus* (1 of 2); *Scomberomorus regalis* (2 of 2).
Site: Pyloric caeca and intestine.

Discussion: My specimens differ slightly from the original description. The eggs measure 17 to 23 by 12 to 15 microns rather than 15 to 17 by 9 to 10, and the ovary does not always overlap the anterior testis.

Bucephaloides bennetti Hopkins and Sparks, 1958

Bucephalopsis bennetti Melugin, 1940 (*nomen nudum*).

Host: *Paralichthys albigutta* (1 of 1).
Site: Pyloric caeca.

Discussion: Sogandares-Bernal and Hutton (1959a:260) gave a review of *B. bennetti.*

Bucephaloides arcuatus (Linton, 1900) Velasquez, 1959

Gasterostomum arcuatum Linton, 1900.
Bucephalopis arcuatus (Linton, 1900) Eckmann, 1932.

Host: *Scomberomorus regalis* (2 of 2).
Site: Pyloric caeca.

Discussion: My specimens agree fairly well with the original description by Linton. They have an excretory vesicle extending to or near the rhynchus, and thus differ from specimens previously reported as *Bucephaloides arcuatus* from barracuda, as discussed by Manter (1963c: 229-230) and confirmed by Nahhas and Cable (1964: 173).

FAMILY FELLODISTOMATIDAE Nicoll, 1913

Tergestia pectinata (Linton, 1905) Manter, 1940

Distomum pectinatum Linton, 1905.
Theledra pectinata (Linton, 1905) Linton, 1910.

Host: *Caranx crysos* (1 of 2).
Site: Rectum.

Discussion: Considerable confusion exists about the identification of some species of *Tergestia*. Manter (1947:323) believed that what Linton reported as *T. pectinata* from *Auxis thazard* and *A. rochei* is actually *T. laticollis*, and that *T. laticollis* of Yamaguti, 1951, is probably *T. pectinata* (see: Manter, 1963b:447). Two specimens 1.8 long from *Caranx crysos* have sucker ratios of 1:1.5 and 1:1.6, which would place them as *T. laticollis* in Manter's key (1954:527). The specimens have a straight seminal vesicle, a character which Manter (1947:323) also used to differentiate *T. laticollis* from *T. pectinata*. However, Sogandares-Bernal and Hutton (1959b:64) noted a straight seminal vesicle in *T. pectinata*, and my specimens have a folded cirrus and eggs 19 to 23 by 12 to 14 microns, characters which Manter (1947:323) regarded as defining *T. pectinata*. I make the identification with reservation because of this confusion and because the specimens appear more like those from *Selene vomer* discussed below, except that the blunt-ended seminal vesicle in specimens from *C. crysos* extends posteriorly, rather than tapering off and curling back to approximately the middle of the posterior border of the acetabulum.

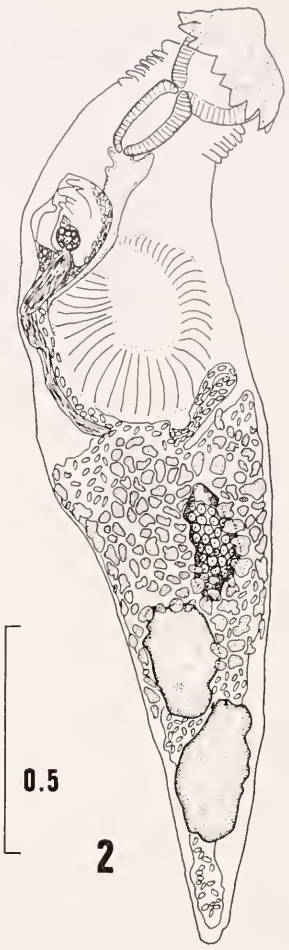


Figure 2. *Tergestia* sp., dorsal view.

Tergestia sp. Figure 2

Host: *Selene vomer* (1 of 2).
Site: Intestine.
Specimen deposited: U. S. N. M. Helm. Coll. No. 71296.

Discussion: This could be a new species as suggested by Siddiqi and Cable (1960: 284) who found the flame cell pattern in a small specimen from *Selene vomer* to differ from that recorded for *Tergestia laticollis*. It is similar to *T. acuta*, although the

vitellaria are not confluent in all my specimens. *Tergestia pauca* Freitas and Kohn, 1965, another similar species, also has numerous vitelline follicles which are dispersed both inter- and extracaecally, although it differs from my specimens in having a sucker ratio of 1:1.97 to 2.34 and differently-shaped terminal genitalia.

Nine mature individuals 1.2 to 2.4 long have 13 oral lobes, sucker ratios 1:1.5 to 1.7, eggs 16 to 23 by 11 to 16 microns, and width of pharynx 45 to 56% of the length. A prostatic vesicle is present in the cirrus sac. The uterus extends to a level posterior to the rear testis in the three larger specimens.

Infundibulostomum spinatum
Siddiqi and Cable, 1960

Host: *Haemulon sciurus* (1 of 6)*.
Site: Intestine.

Discussion: A single specimen differs somewhat from the original description. It measures 1.4 long and has a sucker ratio of 1:0.30. The seminal vesicle is indistinctly bipartite, without an observable external seminal vesicle.

Proctoeces lintoni
Siddiqi and Cable, 1960

Host: *Lagodon rhomboides* (2 of 5)*.
Site: Rectum.

Proctoeces maculatus (Looss, 1901) Odhner, 1911
Distomum maculatum Looss, 1901.
Distomum subtenue Linton, 1907.
Proctoeces erythraeus Odhner, 1911.
Proctoeces subtenuis (Linton, 1907) Hanson, 1950.

Host: *Calamus bajonado* (1 of 1).
Site: Rectum.

Discussion: In view of the variation in specimens from various parts of the world, it seems pertinent to give a few characteristics of my four specimens. They are 1.7 to 2.2 long with sucker ratios of 1:1.5 to 1.8 and eggs 45 to 62 by 19 to 24 microns. They have a long genital sinus and vitellaria extending to a level posterior to the testes. Manter and Pritchard (1962:115-116) gave a review of the species.

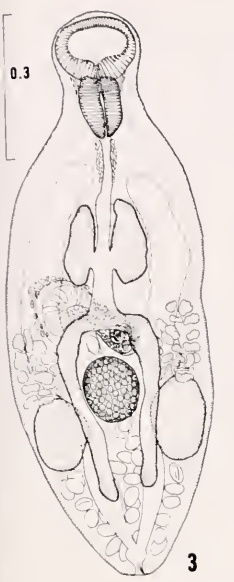
Antorchis urna (Linton, 1910) Linton, 1911

Mesorchis urna Linton, 1910.
Antorchis holacanthi Siddiqi and Cable, 1960 (new synonym).

Hosts: *Holacanthus isabelita* (1 of 1); *Pomacanthus arcuatus* (1 of 4); *Pomacanthus paru* (1 of 1).
Site: Intestine and pyloric caeca.

Discussion: The overlap in characteristics between *Antorchis urna* and *A. holacanthi* is such that the two appear to be synonymous. Dr. R. M. Cable lent three slides with 25 specimens of *A. urna* and four slides with 23 specimens of *A. holacanthi* from Puerto Rico, Curaçao, and Jamaica. Siddiqi and Cable (1960:285) used the general size and shape of the body and pharynx, form of vitellaria, position of testes, extent of uterus, and shape of oral sucker to distinguish between the two species. I can separate Dr. Cable's specimens into two groups by size of body, number and size of vitellaria, and shape of pharynx, although I do not consider them separate species. Of my specimens, eleven from or near the pyloric caeca of *Holacanthus isabelita,* the site and host for *A. holacanthi,* agree in all respects with others from the intestine of *Pomacanthus* spp., the site and hosts for *A. urna.* The lengths are 1.1 to 1.5 and 1.1 to 1.7, the pharynx is spherical to elongate, the vitellaria are relatively large, the posterior border of the testes does not extend to a level anterior to the acetabulum, the uterus extends to or to a level slightly anterior to the testes, and the oral sucker is usually funnel-shaped. Two differences between Dr. Cable's specimens of *A. holacanthi* and mine of *A. urna* are (1) the length of body (up to 1.1 as compared to 1.1 to 1.7), and (2) number but not size of vitellaria (less than 10 as compared to about 20 to 30). The shorter length might be due to host-influence. Also, Linton (1910:47-48) recorded a length of 0.84 for a specimen of *A. urna.* My smaller specimens have fewer vitellaria than the larger specimens, although never less than 10. In view of the variations, I consider *A. holacanthi* a synonym of *A. urna.*

Both wholemounts and sagittal sections



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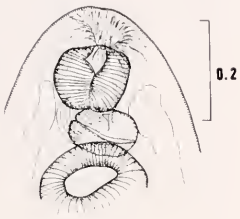

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Figure 3. *Botulisaccus pisceus,* individual with few eggs, dorsal view. Figure 4. *Botulisaccus pisceus,* terminal reproductive organs of different individual, dorsal view.

Figure 5. *Botulisaccus pisceus,* anterior end, ventral view.

show an almost spherical, spined cirrus projecting into a spinous atrium. Siddiqi and Cable (1960:286) incorrectly stated, in contrast to Manter (1947:320), that "the muscular lining of the genital atrium is reflected over the end of the cirrus sac, giving it an annulated appearance . . . ."

Steringotrema corpulentum (Linton, 1905) Manter, 1931

Distomum corpulentum Linton, 1905.

Hosts: *Archosargus rhomboidalis* (4 of 5)*; *Lagodon rhomboides* (1 of 5).
Site: Pyloric caeca.

Botulisaccus pisceus Caballero, Bravo-Hollis, and Grocott, 1955
Figures 3, 4, and 5

Host: *Albula vulpes* (7 of 7).
Site: Intestine, few in pyloric caeca.
Specimen deposited: U. S. N. M. Helm. Coll. No. 71297.

Description (based on 18 wholemounts and 3 sectioned specimens): Body pyriform, 1.0 to 1.8 long by 0.36 to 0.68 in maximum width, usually at or just posterior to level of acetabulum. Cuticle completely spinose. Oral sucker spherical, funnel-shaped, or cup-shaped; 0.07 to 0.18 long by 0.13 to 0.21 wide; sometimes retracted deeply into body (Figure 5). Acetabulum 0.21 to 0.34 long by 0.21 to 0.35 wide. Sucker ratio 1:1.2 to 1.9. Forebody 24 to 36% of body length; usually with a fold in the cuticle at a level just anterior to acetabulum. Prepharynx short. Pharynx large, muscular, oval to barrel-shaped, 0.13 to 0.19 long by 0.07 to 0.12 wide, anterior portion with diagonal rather than radial musculature; muscles extending from a point at middle or posterior of pharynx to oral sucker. Esophagus 0.10 to 0.22 long; anterior region surrounded by glandular cells; with large epitheliated lateral outpouchings located midacetabular to a level immediately anterior to acetabulum. Primary intestinal bifurcation near level of posterior border of acetabulum. Caeca extending to approximately middle of posttesticular region; prominently epitheliated except for some of internal portions.

Testes symmetrical, elongate; right testis 0.16 to 0.29 long by 0.09 to 0.18 wide; left testis 0.16 to 0.28 by 0.07 to 0.18. Posttesticular region 15 to 28% of body length. Cirrus sac muscular, straight to arcuate, 0.20 to 0.38 long, extending from a level immediately posterior to acetabulum to near ovarian level; constricted at level of prostatic vesicle. Cirrus sac containing bipartite seminal vesicle, portions oval, spherical, or irregular; prostatic vesicle wide, longer than seminal vesicle, surrounded by prostatic cells; cirrus short, wide, muscular, unarmed. Genital pore postacetabular, sinistral. Genital atrium wide but constricted at genital pore.

Ovary spherical to ovoid, 0.10 to 0.18 long by 0.07 to 0.16 wide; between testes with ¼ to ¾ of its length above anterior margins of testes. Seminal receptacle lacking; sperm in proximal portion of uterus. Laurer's canal opening dorsally posterior to ovary. Mehlis's gland compact to diffuse. Uterus extensive, extending from cirrus sac to posterior end of body, leaving most of testes

visible. Metraterm short. Vitelline follicles numerous, extending from anterior portion of testes to or near acetabular level. Eggs operculated, thick-walled, 34 to 47 by 23 to 30 microns.

Excretory vesicle V-shaped with arms terminating between midacetabular and pharyngeal levels. Excretory pore dorsal or terminal.

Discussion: My specimens agree with the original description of *Botulisaccus pisceus* with two exceptions: first, I could not see the small spines on the cirrus mentioned by Caballero *et al.* in their generic diagnosis, and, second, they misinterpreted the epitheliated esophageal outpouching as the intestinal bifurcation, which is located dorsal to the cirrus sac.

Caballero *et al.* placed *Botulisaccus* in the Monorchiidae, and Yamaguti (1958:56) transferred it to the Zoogonidae, but Manter and Pritchard (1961:483) thought it belonged in the Monorchiidae. The presence of a V-shaped excretory vesicle, or Y-shaped with an extremely short stem, described here for the first time, and the absence of a spinose cirrus indicate that *Botulisaccus* should be assigned to the Fellodistomatidae. The only unusual fellodistomatid characters of this genus are the postacetabular cirrus sac and genital pore and the esophageal outpouchings.

This species was previously known only from *Albula vulpes* from the Pacific Ocean.

Claribulla gen. n.

Generic diagnosis: Body elongate, spinose. Oral sucker cup-shaped or funnel-shaped. Acetabulum preovarian, enclosed in genital atrium. Pharynx elongate. Caeca long or short. Testes diagonal to tandem. Seminal vesicle preacetabular. Pars prostatica present. Atrial papilla present. Ovary compact, pretesticular. Seminal receptacle absent. Vitellaria in acetabular-ovarian zone. Eggs without filaments. Parasites in marine fishes. Type and only species:

Claribulla **longula** sp. n.
Figures 6 and 7

Hosts: *Albula vulpes* (5 of 7), type hosts; *Sphyraena barracuda* (1 of 1).

Site: Pyloric caeca, few in upper intestine. *Holotype*: U. S. N. M. Helm. Coll. No. 71316, paratype: No. 71376.

Description (based on 15 wholemounts and 1 sectioned specimen): Body bluntly rounded posteriorly, 0.9 to 2.7 long by 0.21 to 0.37 wide, the widest portion generally in hindbody; usually a slight constriction at acetabular level. Entire cuticle with minute spines. Oral sucker 0.10 to 0.24 long by 0.14 to 0.27 wide. Acetabulum enclosed in genital atrium, protrusible, 0.07 to 0.14 long by 0.09 to 0.13 wide. Sucker ratio 1:0.4 to 0.7. Forebody 29 to 44% of body length. Pharynx 0.07 to 0.19 long by 0.04 to 0.08 wide, in contact with oral sucker and connected to it by muscle fibers attached at or near equator of pharynx. Esophagus usually shorter than pharynx. Intestinal bifurcation much nearer oral sucker than acetabulum. Caeca sometimes swollen, extending to between acetabulum and near posterior end of body.

Testes diagonal to almost tandem, usually contiguous, spherical to slightly irregular; anterior testis 0.06 to 0.15 long by 0.08 to 0.18 wide, either sinistral or dextral to posterior testis; posterior testis 0.06 to 0.17 long by 0.10 to 0.16 wide. Posttesticular space 26 to 41% of body length. Cirrus sac absent. Seminal vesicle saccate, straight or bent, extending to a level anterior to or occasionally overlapping acetabulum. Pars prostatica sinuous or nearly straight, extending posteriorly from anterior portion of seminal vesicle; surrounded by numerous free prostatic cells. Ejaculatory duct inconspicuous, short and muscular. Atrial papilla large, muscular, located sinistrally, at a level anterior or lateral to acetabulum, protruding into muscular canal which extends posteriorly to approximately midacetabular level, then joining large muscular genital atrium.

Ovary rounded to slightly irregular, median or submedian, anterior to and almost always in contact with anterior testis, 0.06 to 0.12 long by 0.08 to 0.12 wide. Laurer's canal present. Proximal folds of uterus filled with sperm. Vitelline follicles clustered laterally, extending from ovarian level to or near acetabular level. Uterus extensive, filling most of postovarian spaces and extending to anterior border of acetabu-

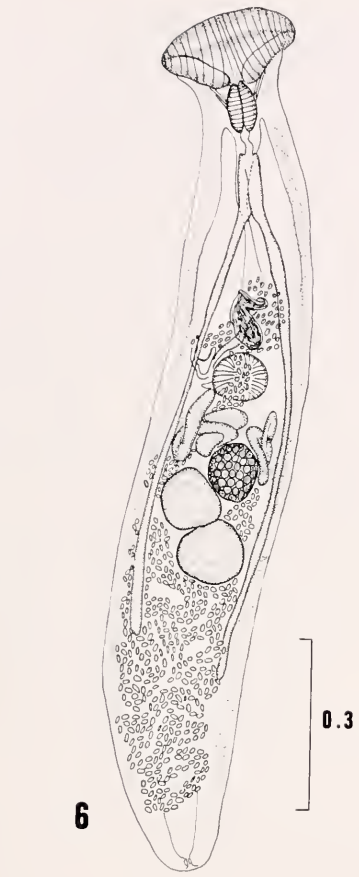


Figure 6. *Claribulla longula,* holotype, dorsal view. Figure 7. *Claribulla longula,* terminal reproductive organs, side view.

lum before joining genital atrium. Eggs usually collapsed, noncollapsed specimens 16 to 30 by 10 to 13 microns; 25 to 29 by 11 to 13 in living specimens.

Excretory vesicle Y-shaped; stem dividing at ovarian level with arms extending to pharyngeal level. Excretory pore terminal.

Discussion: I believe the genus *Claribulla* belongs in the family Fellodistomatidae. If I were to accept the validity of Monodhelminthidae Dollfus, 1937, then *C. longula,* with its atrial papilla, or accessory organ as referred to by Yamaguti, could be placed in that family. However, I am treating this family as a subfamily in the Fellodistomatidae. Yamaguti (1958:256-259) included the genera *Monodhelmis* Dollfus, 1937, *Mehratrema* Srivastava, 1939, *Tandanicola* Johnston, 1927, and *Prosogonarium* Yamaguti, 1952, in the Monodhelminthidae. Of these, *C. longula* resembles the species of *Monodhelmis* and *Tandanicola* by lacking a cirrus sac, although it differs from members of all four genera by having a preovarian acetabulum, an acetabulum enclosed in the genital atrium, and several other individual differences. The relationship of *Tandanicola* with the Fellodistomatidae was previously reported by Cable (1953:417), when he amended Tandanicolinae Johnston, 1927, to include *Megalomyzon* Manter, 1947, and *Pseudosteringophorus* Yamaguti, 1940, both recognized fellodistomatids, and transferred the subfamily from the Brachycoeliidae to the Fellodistomatidae.

Claribulla longula further links the monodhelminthids with the fellodistomatids by being similar to a group of the latter which includes *Pseudobacciger* Nahhas and Cable, 1964, *Bacciger* Nicoll, 1914, *Pentagramma* Chulkova, 1939, and *Faustula* Poche, 1926. *Bacciger* and *Pentagramma* were reviewed by Margolis and Ching (1965) without being assigned to a subfamily because of the unstable classification of the fellodistomatids. *Claribulla longula* differs from species of the above four genera in the arrangement of the gonads, the absence of a seminal receptacle, and the presence of an atrial papilla. A cirrus sac is absent in members of *Pseudobacciger* and indistinct in those of *Pentagramma.* The absence of a cirrus sac in *Pseudobacciger harengulae* (Yamaguti, 1938) (= *Bacciger h.*) and in

the illustration of *B. bacciger* (Rudolphi, 1819) by Stossich (1889) caused Yamaguti (1938 and 1958) to place *Bacciger* in the Heterophyidae and later in the Cryptogonimidae.

The absence of a cirrus sac in conjunction with the atrial papilla in *C. longula* is suggestive of a cryptogonimid. In the superfamily Opisthorchioidea, of which Cryptogonimidae is a member, however, a consistent and conspicuous feature is a seminal receptacle. Also, all known cercariae in that superfamily which leave the snail have eyespots which can be found, at least as scattered granular pigmented remnants, in the forebody of the adult (Cable, 1968: personal communication). If the cercaria of *C. longula* is found to have eyespots, this species should be transferred to the family Cryptogonimidae.

In Digenea lacking the usual protrusible cirrus, numerous modifications of terminal genitalia and adjacent portions are found in non-related groups, including the fellodistomatids. Convergent evolution of these modifications led parasitologists to place the presently recognized Microphallidae and Gymnophallinae as subfamilies of the Heterophyidae. More recent studies on the life histories of these three groups indicate that they represent three distinct orders, with two (Microphallidae and Heterophyidae) in the superorder Epitheliocystidia and one (Gymnophallinae) in the superorder Anepitheliocystidia.

The single specimen from *Sphyraena barracuda* may represent an accidental infection.

The name *Claribulla* is from *clara* (distinct) and *bulla* (knot), and refers to the muscular atrial papilla.

FAMILY PARAMPHISTOMATIDAE Fischoeder, 1901

Cleptodiscus reticulatus Linton, 1910

Host: *Pomacanthus arcuatus* (2 of 4).
Site: Rectum.

FAMILY PRONOCEPHALIDAE Looss, 1902

Barisomum erubescens Linton, 1910

Pleurogonius erubescens (Linton, 1910) Prudhoe, 1944.

Monostomum pomacanthi MacCallum, 1916.

Pleurogonius pomacanthi (MacCallum, 1916) Price, 1931.

Host: *Pomacanthus arcuatus* (1 of 4).
Site: Rectum.

Discussion: Linton (1910:70) implied, as I determine, that the dorsoventral musculature of this worm was very unusual. The internal bundles are roughly situated in rows, separated from adjacent bundles by approximately two bundle widths. They are most prominent in the intercaecal region. A few long crystals in the parenchyma apparently are sponge spicules that entered the worm mechanically.

FAMILY MICROSCAPHIDIIDAE Travassos, 1922

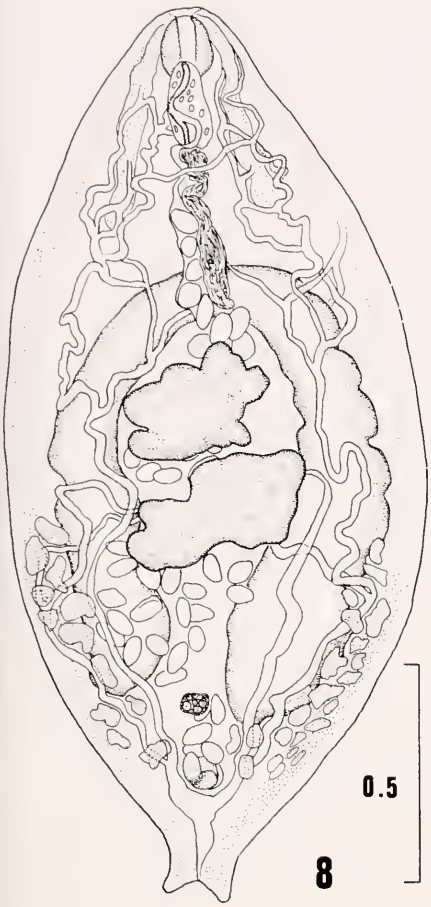
Hexangitrema pomacanthi Price, 1937
Figures 8 and 9

Hexangitrema breviceca Siddiqi and Cable, 1960 (new synonym).

Host: *Pomacanthus arcuatus* (1 of 4).
Site: Intestine and rectum.
Specimen deposited: U. S. N. M. Helm. Coll. No. 71298.

Description (based on 14 wholemounts and 3 sectioned specimens): Body monostomate, broadly fusiform, notched posteriorly, 1.5 to 2.4 long by 0.71 to 1.00 wide. Cuticle smooth. Eyespot pigment present, more conspicuous in smaller specimens. Oral sucker terminal, 0.09 to 0.16 long by 0.11 to 0.15 wide; retrodorsal pockets prominent or retracted and inconspicuous. Esophagus, including bulb at posterior end, 0.24 to 0.49 long, muscular; bulb spherical to elongated. Caeca wide, terminating blindly from 8 to 33% of length of body from posterior end.

Testes tandem, lobed, intercaecal or slightly overlapping caeca, approximately 0.2 to 0.6 long by 0.3 to 0.5 wide. Genital pore near posterior border of oral sucker. Hermaphroditic sac thin-walled elongate; comprised of loosely woven fibrous strands; containing terminal portion of metraterm, prostatic cells, small or no internal seminal



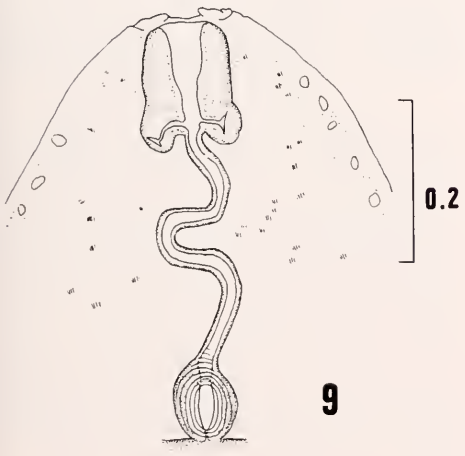


Figure 8. *Hexangitrema pomacanthi,* ventral view. Figure 9. *Hexangitrema pomacanthi,* anterior end.

vesicle, pars prostatica, and long (0.08 to 0.10), narrow, muscular hermaphroditic duct. External seminal vesicle long, sinuous, extending to or posterior to intestinal bifurcation.

Ovary smooth to irregular, 0.09 to 0.16 long by 0.06 to 0.13 wide, posttesticular by a variable distance. Mehlis's gland posterior to ovary. Laurer's canal present, inconspicuous. Vitellaria extracaecal and overlapping caeca ventrally, from between midlevel of either testis to postovarian region, sometimes confluent posterior to ovary. Uterus intercaecal or slightly overlapping caeca; proximal coils filled with sperm. Metraterm long. Eggs thin-shelled, operculate, 79 to 92 by 49 to 59 microns.

Excretory vesicle short, with two main collecting ducts, each dividing into prominent secondary ducts at a level between posterior testis and vesicle. Additional branching present, forming a network of ducts anteriorly. Excretory pore between caudal processes.

Discussion: *Hexangitrema breviceca* Siddiqi and Cable, 1960, is distinguished from *H. pomacanthi* by the presence of lobed, somewhat separated testes and short caeca that do not reach the posttesticular region. My specimens show gradations in the separation of testes from touching to being well separated, in the extent of the caeca which terminate between the midlevel of the posterior testis and beyond the ovary, and in the degree of lobation of the testes. The testes, however, are never completely spherical as illustrated by Price (1937, Figure 5). Many of my specimens were over 4 in length before fixation. Because of these intergradations and variations, I am placing *H. breviceca* as a synonym of *H. pomacanthi.*

The hermaphroditic sac is difficult to interpret in many wholemounts and has not previously been described for *H. pomacanthi.* Sectioned material reveal its structure is similar to that which Looss (1902:676-682, figs. 121, 139) described and illustrated in species of *Microscaphidium* and *Angiodictyum.* These genera are related to *Hexangitrema* and include species in marine turtles. Yamaguti (1958) placed these genera in Angiodictyidae Looss, 1902. I agree with

Stunkard (1943:143) in suppressing Angiodictyidae and accepting Microscaphidiidae Travassos, 1922, as the only available name.

FAMILY HAPLOPORIDAE Nicoll, 1914

Vitellibaculum spinosum (Siddiqi and Cable, 1960) Durio and Manter, 1968

Allomegasolena spinosa Siddiqi and Cable, 1960.

Host: *Chaetodipterus faber* (1 of 2).
Site: Posterior intestine.

Discussion: Four specimens 1.8 to 2.4 long have cuticular spines extending to or almost to posterior end in addition to spines at terminal portion of body, pharynx 0.18 to 0.19 long by 0.12 to 0.14 wide and pyriform in shape, and eggs 62 to 75 by 39 to 43 microns. Sucker ratios are 1:1.3 to 1.9 and appear to be dependent on the state of contraction of the oral sucker at the time of fixation. The forebody is attenuated in three of the specimens. In a 1.6 long curled specimen with two eggs, lent by Dr. R. M. Cable, the pharynx is barrel-shaped and 0.12 long by 0.095 wide. The variations in shape of body, sucker ratio, and size of pharynx, in addition to the report of *Vitellibaculum spinosum* from both *Chaetodipterus faber* and *Lutjanus apodus* (see: Nahhas and Cable, 1964:179), all suggest that additional specimens of *V. attenuatum* (Siddiqi and Cable, 1960) from *L. apodus*, the type host, may well show *V. attenuatum* to be a synonym of *V. spinosum*.

Dr. Manter has unreported specimens of *V. spinosum* from *C. faber* that he has identified from his collection from Beaufort, North Carolina.

Megasolena hysterospina (Manter, 1931) comb. n.
Figure 10

Lepidauchen hysterospina Manter, 1931.
Megasolena archosargi Sogandares-Bernal and Hutton, 1959 (new synonym).

Host: *Archosargus rhomboidalis* (4 of 5).
Site: Intestine.
Specimen deposited: U. S. N. M. Helm. Coll. No. 71299.

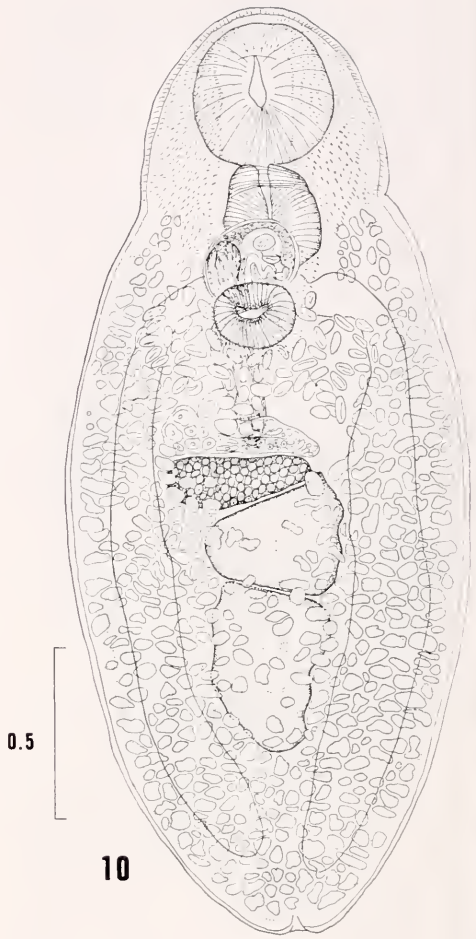


Figure 10. *Megasolena hysterospina*, ventral view.

Discussion: Examination of a paratype of *Lepidauchen hysterospina*, lent by Dr. H. W. Manter, revealed that species to have a hermaphroditic sac instead of a cirrus sac. This species is therefore in the genus *Megasolena* Linton, 1910, with *M. hysterospina* as a new combination. Prévot (1968) recently studied adult and larval *L. stenostoma* Nicoll, 1913, and found that a seminal receptacle was present and a hermaphroditic sac absent. He concluded that *Lepidauchen* Nicoll, 1913, belonged in the subfamily Lepocreadiinae Odhner, 1905.

I consider *M. archosargi* Sogandares-Bernal and Hutton, 1959, a synonym of *M.*

hysterospina. *Megasolena hysterospina* is described as not having an esophagus or external seminal vesicle. My specimens have both, but they are difficult or impossible to see in some individuals. A Laurer's canal is present; it was not observed in *M. archosargi*. The hermaphroditic sac varies in shape from elongate to almost spherical, with its posterior extension lying between the anterior and posterior borders of the acetabulum. A tubular prostatic vesicle is present. The vitelline follicles containing yolk granules agree with the descriptions; some gland cells not containing granules, however, extend anteriorly to these. A ventral cuticular area, usually present as a groove and bordered by spines, extends between the suckers and includes their apertures. The bordering spines were observed on specimens lent by Dr. R. M. Cable from his Jamaican collection and were seen to extend only to the midacetabular level on Dr. H. W. Manter's specimen.

Additional measurements on 12 of my mature specimens are: Body 1.9 to 3.9 long by 0.99 to 1.56 wide. Oral sucker 0.33 to 0.68 long by 0.34 to 0.54 wide. Acetabulum 0.16 to 0.35 by 0.20 to 0.38. Sucker ratio 1:0.6 to 0.8. Forebody 26 to 34% of body length. Prepharynx contracted or up to 0.13 long. Pharynx 0.22 to 0.46 long by 0.19 to 0.34 wide. Anterior testis 0.20 to 0.55 long by 0.36 to 0.85 wide; posterior testis 0.38 to 0.73 by 0.37 to 0.74. Ovary 0.13 to 0.21 long by 0.32 to 0.65 wide; Dr. Cable's specimens also have ovaries wider than long. Eggs 56 to 83 by 35 to 47 microns.

FAMILY HAPLOSPLANCHNIDAE Poche 1925

Schikhobalotrema sparisoma (Manter, 1937) Skrjabin and Guschanskaja, 1955

Haplosplanchnus sparisoma Manter, 1937.

Host: *Nicholsina usta* (2 of 3)*.
Site: Intestine.

Schikhobalotrema kyphosi (Manter, 1947) Skrjabin and Guschanskaja, 1955

Haplosplanchnus kyphosi Manter, 1947.

Host: *Kyphosus sectatrix* (3 of 6).

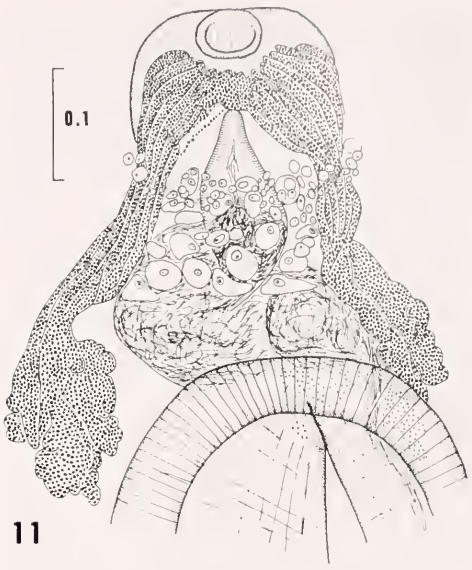


Figure 11. *Schikhobalotrema acutum*, genital bulb and associated structures, ventral view.

Site: Pyloric caeca, occasionally in upper intestine.

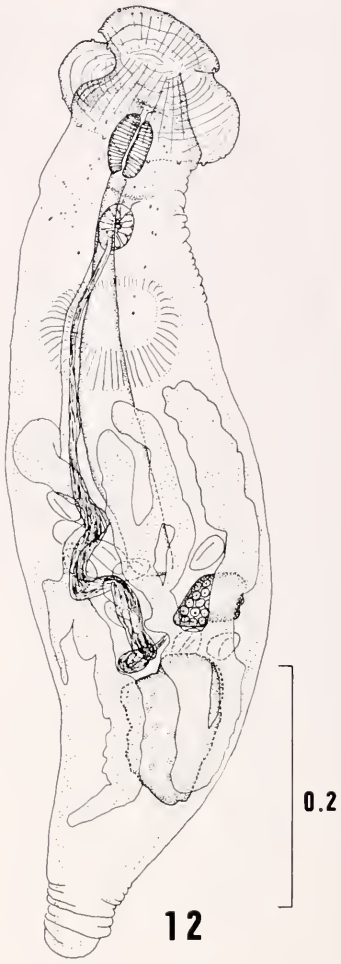
Additional measurements and discussion: Six specimens 1.9 to 2.8 long by 0.52 to 0.79 wide have sucker ratios of 1:0.6 to 1.1, depending on the expansion of the oral sucker. The oral sucker is 0.29 to 0.46 wide, and the acetabulum is 0.23 to 0.35 wide. Forebody is 26 to 36% of the body length. Pharynx is 0.11 to 0.17 long by 0.12 to 0.17 wide. Eggs are 80 to 92 by 51 to 64 microns. The anterior limit of the excretory vesicle may reach the level of the pharynx, and the extremely sinuous seminal vesicle may extend posterior to the testis. Sensory papillae are prominent on the oral sucker and anterior end, as Manter (1937b:385) predicted for all species of "*Haplosplanchnus*."

Schikhobalotrema acutum (Linton, 1910) Skrjabin and Guschanskaja, 1955
Figure 11

Deradena acuta Linton, 1910.
Haplosplanchnus acutus (Linton, 1910) Manter, 1937.

Host: *Strongylura timucu* (1 of 3).
Site: Rectum.

Discussion: Sogandares-Bernal and Sogandares (1961:145-147) reviewed this species and considered *Schikhobalotrema* as a subgenus of *Haplosplanchnus*. There is considerable range in length, an important character used to distinguish this species from *S. adacutus*. The previous authors reported a specimen of 0.6, without eggs, from *Abudefduf saxatilis* (= *A. marginatus* as used by Manter, 1937), a host of the smaller *S. adacutus*. Siddiqi and Cable (1960:Figure 16) illustrated a specimen of 0.7 from a beloniform, the typical host for *S. acutum*. Manter (1937b:385) discussed specimens of 1.3 to 2.0 long and Caballero *et al.* (1953: 128) others 1.6 to 2.1 from the Pacific Ocean, all from beloniform fishes. My specimens are 2.1 to 2.5 with sucker ratios of 1:1.2 to 1.4 and have eggs 85 to 88 by 53 to 57 microns. Sensory papillae are present around the oral sucker. Manter (1937b: 386) described longitudinal striae dividing the muscular genital bulb. The dorsal portion of this bulb in my specimens appears corrugated and the ventral portion is covered by a series of tubules which are filled with granules (Figure 11). The tubules extend posteriorly, dividing into two groups at the midlevel of the bulb. Both groups lead to large reservoirs of granules, which appear like yolk granules, located on each side of the acetabulum.



Hymenocotta **manteri** sp. n.
Figures 12 and 13

Host: *Mugil cephalus* (3 of 3), type host.
Site: Intestine and pyloric caeca.
Holotype: U. S. N. M. Helm. Coll. No. 71300, paratype: No. 71366.

Description: (based on 16 wholemounts and 3 sectioned specimens): Body elongate, 0.9 to 1.6 long by 0.27 to 0.45 at maximum width, usually near acetabular level. Cuticle thick, with prominent rings, especially in tapering hindbody. Pigment granules scattered in forebody and occasionally throughout entire worm. Oral sucker replaced by

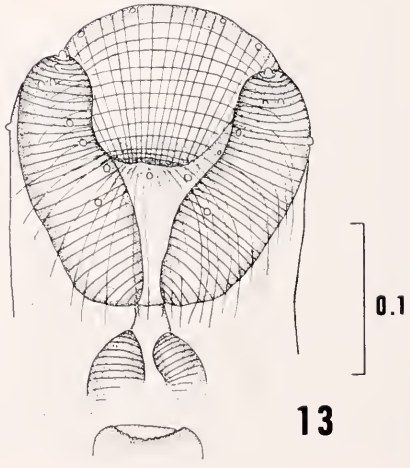


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Figure 12. *Hymenocotta manteri*, holotype, dorsal view. Figure 13. *Hymenocotta manteri*, contracted oral disc, ventral view.

oral disc which may be flared out, or contracted (Figure 13) and superficially resembling spherical or cup-shaped oral sucker; 0.15 to 0.33 wide at greatest diameter, depending on individual variation and contraction. Numerous sensory papillae on disc. Acetabulum protrusible, without lobes, 0.16 to 0.25 long by 0.17 to 0.27 wide; aperture a circular to longitudinal slit-like opening. Sucker ratio 1:0.6 to 1.3. Forebody 26 to 36% of body length. Prepharynx about ½ length of pharynx. Pharynx 0.07 to 0.10 long by 0.06 to 0.09 wide. Single caecum usually approaching or extending well into testicular level; highly cellular, often containing particulate matter.

Testis elongate, spherical, or slightly irregular, not touching acetabulum; 0.13 to 0.19 long by 0.09 to 0.20 wide. Posttesticular space 11 to 39% of body length, depending on contraction. Cirrus sac absent. Seminal vesicle tubular, long, extending near or well into testicular level; straight to highly sinuous; often with several loops directly anterior or posterior to acetabulum; connected to spherical prostatic vesicle by pars prostatica of greater length than vesicle. Genital atrium muscular. Genital pore median or submedian, at a level near posterior of pharynx.

Ovary subglobular, 0.06 to 0.12 long by 0.05 to 0.12 wide, variable in position from anterior acetabular level to posterior border of testis, usually anterolateral to testis. Seminal receptacle dorsal, near ovarian level. Vitelline follicles usually in elongate groups, extending from level of acetabulum or slightly posteriorly to a level midway between testis and posterior end of body. Uterus may extend to midtesticular level before turning anteriorly. Metraterm present. Eggs usually partially collapsed, 66 to 89 by 35 to 48 microns; not containing fully-developed miracidia.

Excretory pore terminal; vesicle bifurcating at midtesticular level with arms extending to near posterior border of pharynx.

Discussion: Manter (1961:67-69) erected the genus *Hymenocotta* to accommodate a single species, *H. mulli* Manter, 1961, which differs from all other haplosplanchnids in having a cirrus sac and a six-lobed disc, which replaces the oral sucker. The present species is the second with a disc, but it is not six-lobed, and a cirrus sac is absent. What appears to be the cirrus sac is weakly developed and not evident in all of Dr. Manter's specimens of *H. mulli* from New Caledonia (Manter, 1968:personal communication). Pending further information, the present species is placed in *Hymenocotta* because of the oral disc which, with the absence of a well-developed bulb of prostatic ducts, distinguishes *H. manteri* from *Schikhobalotrema elongatum* Nahhas and Cable, 1964, an otherwise similar species from the same host.

This species is named in honor of Dr. Harold Winfred Manter, in recognition of his contributions to the field of trematodology.

FAMILY LEPOCREADIIDAE Nicoll, 1934

Thysanopharynx elongatus Manter, 1933

Host: *Lactophrys quadricornis* (1 of 3).
Site: Intestine.

Discussion: Manter (1963a:107) reduced the family Megaperidae Manter, 1934, which would include this and the following species, to a subfamily in the Lepocreadiidae. Nahhas and Cable (1964:179) tentatively accepted Megaperidae and placed it in the superfamily Haploporoidea Mehra, 1961, along with the haploporids and haplosplanchnids. They also noted that *Enenterum* and *Cadenatella,* generally placed in the Lepocreadiidae, have features in common with members of the Haploporoidea and that they might later be transferred to that group. Pending life history studies, however, they retained the two genera in the Lepocreadiidae. I also prefer to retain them, as well as *Thysanopharynx* and *Megapera,* with the lepocreadiids.

Megapera sp.

Host: *Lactophrys quadricornis* (1 of 3).
Site: Intestine.

Discussion: A single immature individual is included in this study because *Lactophrys quadricornis* is the final host for several species of *Megapera.* It is 0.51 long and has a constricted hindbody as in *M. gyrina,* although the vitellaria extend from the posterior end to the testes as in *M. pseudogyrina* and *M. ovalis.* The sucker ratio is 1:0.29.

Enenterum aureum Linton, 1910

Host: *Kyphosus sectatrix* (5 of 6).
Site: Rectum and posterior intestine.

Cadenatella americana Manter, 1949

Host: *Kyphosus sectatrix* (4 of 6).
Site: Intestine.

Discussion: The forebody, especially the the ventral region, contains individual gland cells opening to the exterior. The elongate or spherical prostatic vesicle generally extends posteriorly, and dorsal to the acetabulum, rather than along its anterior border, as in the holotype. A sectioned specimen does not have a cirrus sac, confirming what Nahhas and Cable (1964:192) believed. A thin membrane, however, appears to surround the vesicle in some wholemounts.

Cadenatella **floridae** sp. n.
Figures 14, 15, and 16

Host: *Kyphosus sectatrix* (5 of 6), type host.
Site: Pyloric caeca and occasionally anterior intestine.
Holotype: U. S. N. M. Helm. No. 71301, paratype: No. 71367.

Description (based on 10 mature wholemounts and 2 sectioned specimens): Body elongate, 3.0 to 4.7 long by 0.31 to 0.44 wide; largest immature specimen 3.01. Cuticle spinose from anterior end to testicular level. Eyespot remnants present; brownish-yellow pigment scattered through parenchyma. Oral sucker 0.10 to 0.16 in diameter with 8 muscular preoral lobes, 4 dorsal and 4 ventral. Acetabulum 0.15 to 0.19 long, 0.14 to 0.19 wide, and 0.12 to 0.17 deep; the surrounding cuticle with an inner ring of papillae adjacent to cuticular spines. Sucker ratio 1:1.1 to 1.5. Forebody 21 to 43% the length of body, with 8 to 11 midventral accessory suckers; occasionally 1 or 2 suckers ventral to posterior portion of pharynx, never anterior to pharynx; the second sucker anterior to acetabulum usually largest, 0.08 to 0.12 wide; smallest sucker 0.04 to 0.06 wide. Prepharynx 0.06 to 0.42, depending on contraction. Pharynx massive, pyriform, 0.22 to 0.32 long by 0.09 to 0.14 wide. Esophagus from 0.09 to 0.24 long; large muscular sphincter at anterior end. Caeca extending to posterior end of body, joining excretory vesicle to form uroproct with terminal pore.

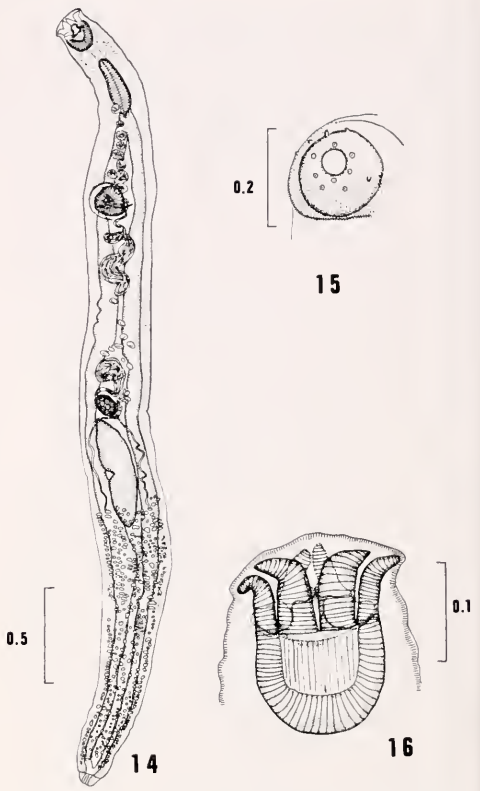

Figure 14. *Cadenatella floridae*, holotype, ventral view. Figure 15. *Cadenatella floridae*, acetabular region, ventral view. Figure 16. *Cadenatella floridae*, anterior end, dorsal view.

Testis single, elongate, occasionally with indentation, 0.32 to 0.73 long by 0.10 to 0.21 wide. Posttesticular region 21 to 40% of body length. Cirrus sac absent. Seminal vesicle long, sinuous, extending to about midway between acetabulum and ovary. Prostatic vesicle spherical to ovoid, near anterior border of acetabulum. Ejaculatory duct short. Genital atrium muscular, inconspicuous in wholemounts. Genital pore in invagination leading to posterior accessory sucker.

Ovary globular to almost triangular; 0.08 to 0.14 long by 0.11 to 0.19 wide; slightly anterior to or overlapping forward portion of testis. Seminal receptacle of uterine type, at a level anterior to ovary. Mehlis's gland near seminal receptacle. Laurer's canal opening dorsal to ovary. Uterus preovarian, intercaecal or occasionally overlapping caeca.

Metraterm present. Vitelline follicles dorsal, ventral, and lateral to caeca and testis; extending from posterior ⅓ of testicular level to end of body; filling most of posttesticular space. Gland cells not containing granules extending from near anterior level of testis almost to pharyngeal level. Eggs thin-shelled, 41 to 72 by 30 to 40 microns for partially-collapsed eggs; 48 to 58 by 31 to 34 microns for noncollapsed eggs.

Excretory vesicle Y-shaped, bifurcating at ovarian level; arms extending about midway between acetabulum and ovary; excretory canals extending from tips of arms to oral sucker then posteriorly through hindbody.

Discussion: Five other species of *Cadenatella* have been described, all from fishes of the genus *Kyphosus*. Only two, *C. brumpti* (Dollfus, 1946) and *C. kyphosi* Nahhas and Cable, 1964, have more than two accessory suckers. The present species differs from both by having 8 to 11 rather than 14 to 17 accessory suckers, by the extension of spines on the ventral side of the body, and probably by possessing a muscular esophageal sphincter. It resembles *C. kyphosi* in size and oral lobes but differs in the location of the accessory suckers. Papillae near the acetabulum (Figure 15) probably are sensory in function; they have not been described for any other species of *Cadenatella*.

Nahhas and Cable (1964:191-192) discussed the known species and considered *Jeancadenatia* a synonym of *Cadenatella*. Sogandares-Bernal (1959:80) clarified some of the provisional description of *C. brumpti* by Dollfus (1946:124-126).

Lepocreadium trulla (Linton, 1907) Linton, 1910

Distomum trulla Linton, 1907.

Host: *Ocyurus chrysurus* (3 of 5).
Site: Intestine.

Discussion: Six specimens 0.9 to 1.2 long have sucker ratios of 1:0.7 to 0.9 and eggs 49 to 56 by 29 to 35 microns. The pharynx is lobed anteriorly. The anterior extent of the excretory vesicle was observed in a living specimen to vary from the pharyngeal level to one a short distance posterior to the intestinal bifurcation. Sogandares-Bernal and Hutton (1960:282) discussed that feature in fixed specimens and Hanson (1950:78) gave measurements of small individuals, also from *Ocyurus chrysurus*.

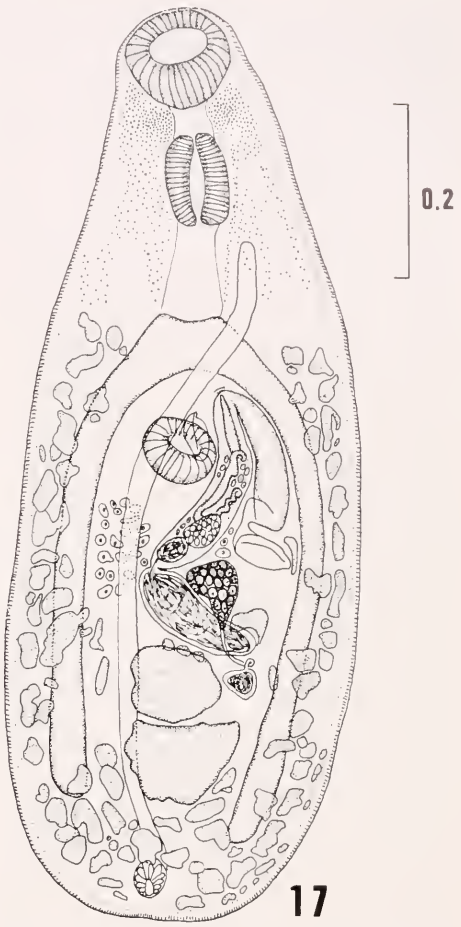

Figure 17. *Lepocreadium pyriforme*, ventral view.

Lepocreadium pyriforme (Linton, 1900) Linton, 1940
Figure 17

Distomum pyriforme Linton, 1900.

Host: *Sardinella anchovia* (1 of 3)*.
Site: Pyloric caeca.
Specimen deposited: U. S. N. M. Helm. Coll. No. 71302.

Discussion: Variations within *Lepocreadium pyriforme* make the status of that species uncertain, as discussed by Sogandares-Bernal and Hutton (1960:280-282) in regard to specimens from different hosts

which Linton identified as *L. pyriforme*. Nahhas and Cable (1964:188) and Nahhas and Short (1965:43) accepted as *L. pyriforme* only individuals resembling Figure 47 (Linton, 1940) or Figure 9 (Sogandares-Bernal and Hutton, 1960), both drawn from specimens from *Palinurichthys perciformis* (Mitchill), the type host. Mine differ from those figures illustrated in the extent of vitellaria, length of the prepharynx, shape and extent of the external seminal vesicle, and sucker ratio. In some of those respects, they are more like those illustrated by the above authors from other hosts. I am provisionally placing my specimens in *L. pyriforme* and describing them, so when adequate material is examined, they can be placed in the proper species.

Description (based on 4 specimens): Body 0.96 to 1.06 long by 0.32 to 0.40 in maximum width. Oral sucker 0.10 to 0.12 long by 0.10 to 0.12 wide. Acetabulum 0.07 to 0.08 by 0.07 to 0.09. Sucker ratio 1:0.7 to 0.08. Forebody 42 to 45% of body length. Prepharynx approximately ½ as long as pharynx width. Pharynx 0.09 to 0.10 long by 0.07 wide. Esophagus as long as, or longer than, pharynx. Caeca ending at level of posterior border of rear testis to midlevel of posttesticular space.

Testes tandem, slightly irregular; anterior testis 0.07 to 0.09 long by 0.10 to 0.12 wide; posterior testis 0.09 to 0.10 by 0.10 to 0.13. Posttesticular space 12 to 18% of body length. Genital pore anterior and sinistral to acetabulum. Cirrus sac 0.11 to 0.21 long by 0.05 wide, posterior extent from midway between acetabulum and ovary to ovarian level. External seminal vesicle elongate, large, approaching size of cirrus sac; terminating in zone of anterior testis.

Ovary smooth, 0.05 to 0.08 long by 0.06 to 0.07 wide. Seminal receptacle sinistral to and usually touching anterior testis. Metraterm muscular, over ¾ as long as cirrus sac. Vitelline follicles from level of intestinal bifurcation to posterior end of body. Eggs partially collapsed, 57 to 71 by 26 to 37 microns.

Excretory pore terminal or subdorsal; vesicle extending intercaecally from pore, on dextral side, then crossing the left caecum near intestinal bifurcation and ending in the left side of forebody at anterior esophageal level.

Lepocreadium floridanum Sogandares-Bernal and Hutton, 1959

Host: *Lagodon rhomboides* (2 of 5).
Site: Pyloric caeca.

Discussion: Twenty-two specimens are 0.4 to 1.2 long and have sucker ratios of 1:0.9 to 1.2. The eggs are within the range given by Nahhas and Short (1965:43); those from living specimens were 62 to 66 by 32 to 40 microns. Extent of the excretory vesicle in a living individual was observed to vary between the bifurcal and anterior esophageal level.

Pseudocreadium scaphosomum Manter, 1940

Hypocreadium scaphosomum (Manter, 1940) Yamaguti, 1942.

Host: *Monacanthus hispidus* (3 of 6)*.
Site: Intestine.

Discussion: Opinion differs as to synonymy between *Hypocreadium* Ozaki, 1936, and *Pseudocreadium* Layman, 1930, and also among the various species assigned to those genera. Sogandares-Bernal (1959:75) and Nahhas and Cable (1964:193) considered *Hypocreadium* a synonym of *Pseudocreadium*, and Manter (1946:414) questioned whether the same may be true of *P. scaphosomum* Manter, 1940, and *P. lamelliforme* (Linton, 1907). Also Bravo-Hollis and Manter (1957:38) were hesitant as to whether *P. scaphosomum* was a synonym of *P. patellare* (Yamaguti, 1938). *Pseudocreadium lamelliforme* (Linton, 1907) and *P. myohelicatum* (Bravo-Hollis and Manter, 1957) are usually separated from *P. patellare* and *P. scaphosomum* by possessing some vitelline follicles which overlap the caeca ventrally. However, Sogandares-Bernal (1959: 76) found at least a few such follicles in a series of paratypes of *P. scaphosomum* and considered *P. myohelicatum* its synonym.

My specimens can be placed in three groups: one of 5 individuals 1.0 to 1.3 long with eggs 51 to 80 by 35 to 47 microns are from 2 specimens of *M. hispidus* 9 cm long; another of 7 individuals 1.5 to 1.7 long with eggs 56 to 71 by 39 to 43 microns are from 1 specimen of *M. hispidus* 26 cm long; and a third of 17 individuals 0.9 to 1.6 long with eggs 56 to 75 by 32 to 43 microns are from 3 specimens of *Balistes*

capriscus. The three groups are alike in most respects: they have smooth to lobed gonads; long, sinuous, divided prostatic vesicle; sinuous cirrus when inverted; variable extent of caecal undulations; genital pore ventral or slightly anterior to caeca; and extremely muscular distal portion of the metraterm. I place these specimens in two species, primarily on the basis of their vitelline arrangement; that is: *P. scaphosomum* from *M. hispidus* and *P. lamelliforme* from *B. capriscus*. Although vitellaria in a few specimens of *P. scaphosomum* are partially ventral to the caeca, the worms from *M. hispidus* are distinct from *P. lamelliforme* and five paratypes of *P. myohelicatum* on a slide lent by Dr. H. W. Manter. The vitellaria in *P. myohelicatum* are not intensive or in clusters and neither *P. lamelliforme* nor *P. myohelicatum* have vitellaria restricted from the caecal zone as in *P. scaphosomum*. For this reason, I consider *P. myohelicatum* a valid species, rather similar to *P. balistis* Nagaty, 1942 (originally *P. balistes*), which also has a short, reasonably straight prostatic vesicle, but a distinctly-partitioned external seminal vesicle. The internal seminal vesicle is extremely muscular, especially in *P. scaphosomum*, and may be spherical, bipartite, or teardrop in shape, depending on contraction. Width of muscular constriction of the prostatic vesicle varies, and the external seminal vesicle may be sinuous, tubular, or saccate.

Additional observations may reveal that *P. patellare* is conspecific with *P. scaphosomum*, and *P. lamelliforme* with *P. myohelicatum*, or possibly that all four are the same species. Illustrations of *P. scaphosomum* from *B. polylepis* by Lamothe (1963:102-108) and Caballero *et al.* (1953:117–121) indicate variability of that trematode.

Pseudocreadium lamelliforme (Linton, 1907) Manter, 1946

Distomum lamelliforme Linton, 1907 (in part).

Host: *Balistes capriscus* (2 of 4).
Site: Intestine.

Discussion: The excretory sphincter in my species of *Pseudocreadium*, especially *P. lamelliforme*, gives a false impression of 5 to 10 large, radial spines.

Nahhas and Cable (1964:193-194) described *P. lactophrysi* and pointed out that Linton (1907:108-109) probably considered that species, *Dermadena lactophrysi*, and *P. lamelliforme* as a single species.

Dermadena lactophrysi Manter, 1946

Distomum lamelliforme Linton, 1907 (in part).

Host: *Lactophrys quadricornis* (2 of 3).
Site: Intestine.

Neoapocreadium coili (Sogandares-Bernal, 1959) Siddiqi and Cable, 1960

Apocreadium coili Sogandares-Bernal, 1959.

Host: *Balistes capriscus* (1 of 4).
Site: Intestine.

Discussion: My single specimen is 3.3 long by 1.0 wide, with a forebody 37% the length of the body. The sucker ratio is 1:0.90, and the eggs measure 80 to 82 by 52 to 54 microns. The sucker ratio and amount of posttesticular space, characters used to separate *N. coili* from *N. bravoi* (Sogandares-Bernal, 1959), are intermediate between values for the two species. The confluent preacetabular vitellaria, however, are numerous, rather than sparse as illustrated for *N. bravoi*. There appears to be a misprint in the description (Sogandares-Bernal, 1959:83): the body width of *N. coili*, as illustrated, should be about 0.69 rather than 0.225, as given in the text.

When additional life history studies of trematodes belonging in the Lepocreadiidae and related families are collected, I believe the genera *Apocreadium* Manter, 1937, *Neoapocreadium* Siddiqi and Cable, 1960, *Postporus* Manter, 1949, and others will be transferred to a separate family. But until the limits of such a group are better defined, I prefer to leave the above three genera in the Lepocreadiidae.

Apocreadium mexicanum Manter, 1937

Host: *Balistes capriscus* (1 of 4)*.
Site: Intestine.

Discussion: Three immature worms are 1.8 to 3.3 long, and even though Manter (1937a:11) reported a mature specimen of *A. mexicanum* 2.2 long, I believe only one species is involved. The lymphatic vessels are branched, and the vitellaria extend anteriorly to the posterior edge of the acetabulum. The largest specimen has a fore-

body 23% the length of the body and a posttesticular space 43% that length; the sucker ratio is 1:1.6. The smaller specimens have longer forebodies, shorter posttesticular areas, and smaller sucker ratios. Siddiqi and Cable (1960:306) and Nahhas and Cable (1964:190) discussed some of the variability of this species.

Apocreadium foliatum (Siddiqi and Cable, 1960) comb. n.
Figure 18

Homalometron foliatum Siddiqi and Cable, 1960.

Hosts: *Haemulon aurolineatum* (1 of 7)*; *Haemulon carbonarium* (1 of 1)*; *Haemulon parrai* (3 of 7)*.
Site: Intestine.
Specimen deposited: U. S. N. M. Helm. Coll. No. 71303.

Discussion: I place this species in the genus *Apocreadium* because it possesses a prominent lymphatic system. There are two pairs of longitudinal vessels which extend almost the entire length of the body and give off numerous branches, primarily in the hindbody.

My 13 wholemounts and 2 sectioned specimens are 1.5 to 5.5 long by 0.44 to 0.85 wide, with an immature specimen 1.74 long. The cuticular spines cover the entire body of immature specimens but only near the testicular level in adults. The prepharynx may be as short as 1/3 that of the pharynx and the seminal vesicle overlaps or is slightly anterior to the ovary, predominantly on the left side. Eggs are 85 to 98 by 48 to 62 microns. With the exception of being larger worms with correspondingly larger organs, my specimens agree with those from *Haemulon sciurus,* lent by Dr. R. M. Cable from his Jamaican collection. Nahhas and Cable (1964:184) discussed specimens which had vitellaria extending to the ovarian level and had a larger body, wider range in sucker ratio, and larger eggs than in those of the original description. The excretory vesicle in my specimens and the borrowed ones extends only to or slightly beyond the posterior border of the rear testis, rather than to the anterior testis.

Apocreadium foliatum differs from *A. balistis* Manter, 1947, *A. caballeroi* Bravo-Hollis, 1953, *A. longisinosum* Manter, 1937, *A. mexicanum* Manter, 1937, and *A. syna-*

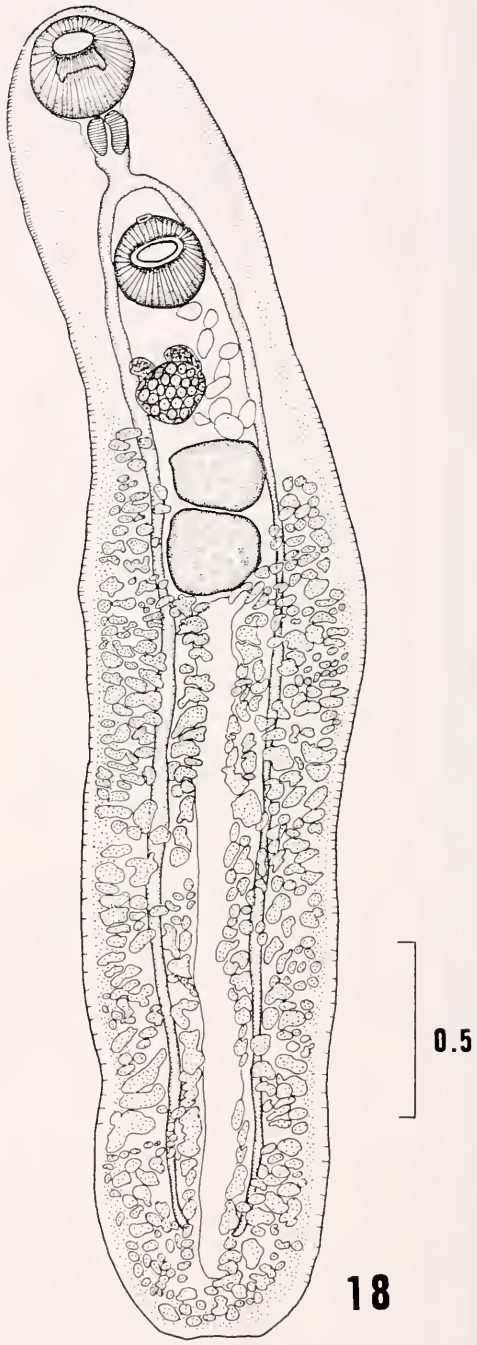

Figure 18. *Apocreadium foliatum,* ventral view.

gris Yamaguti, 1953, in usually having an acetabulum smaller than the oral sucker. In this respect, *A. folliatum* is more like the species of *Apocreadium* described below.

Apocreadium **cryptum** sp. n.
Figure 19

Hosts: *Anisotremus virginicus* (1 of 6); *Haemulon parrai* (1 of 7), type host; additional hosts from Florida Keys cited in discussion.

Site: Pyloric caeca and intestine.

Holotype: U. S. N. M. Helm. Coll. No. 71304, paratype: No. 71368.

Description (based on 6 mature specimens from Biscayne Bay and Florida keys): Body elongate, 4.5 to 9.3 long by 0.98 to 1.53 in maximum width, hindbody extremely foliate usually with median indentation at posterior extremity. An immature individual 4.0 long. Cuticle thick, unspined. Little, if any, eyespot pigment in mature specimens; more conspicuous in immature individuals. Oral sucker funnel-shaped, 0.71 to 1.01 long by 0.68 to 1.37 wide. Acetabulum 0.34 to 0.54 long by 0.30 to 0.59 wide. Sucker ratio 1:0.4 to 0.5. Forebody 30 to 36% of body length. Prepharynx longer or shorter than pharynx. Pharynx 0.19 to 0.32 long by 0.20 to 0.36 wide, without prominent anterior circular muscle band. Length of esophagus variable, up to 80% as long as pharynx. Intestinal bifurcation midway between suckers or closer to oral sucker. Caeca narrow, terminating blindly near posterior end of body.

Testes lobate, tandem, intercaecal, in contact or separated; separated to a greater extent in larger specimens; anterior testis 0.15 to 0.31 long by 0.28 to 0.38 wide; posterior testis 0.19 to 0.41 by 0.26 to 0.35. Posttesticular region 31 to 40% of body length. Cirrus sac absent. Seminal vesicle saccate, extending to roughly midway between acetabulum and ovary. Entire length of pars prostatica surrounded by prostatic cells, more conspicuous and numerous anteriorly. Genital atrium tubular. Genital pore median or slightly submedian, anterior to or ventral to acetabulum.

Ovary smooth or slightly irregular, 0.11 to 0.30 long by 0.20 to 0.28 wide; anterior and slightly dextral to anterior testis, separated by either more or less than length of testis. Seminal receptacle between seminal vesicle and ovary. Mehlis's gland between ovary and anterior testis. Vitelline follicles numerous, those containing yolk extending from level between seminal vesicle and acetabulum to posterior end of body; smaller

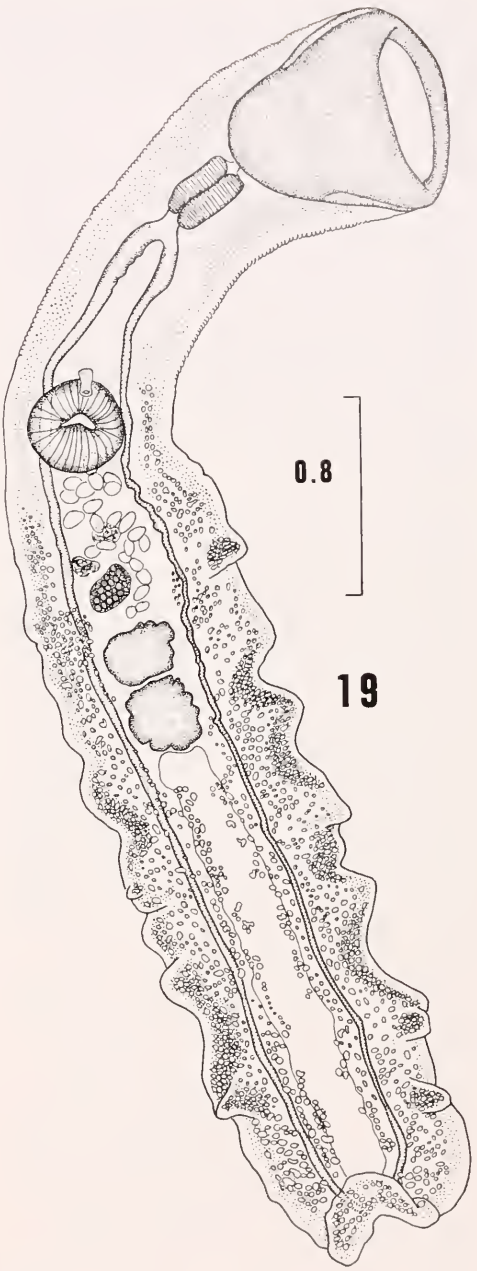

Figure 19. *Apocreadium cryptum*, holotype, ventral view.

gland cells, without yolk granules, extending forward to oral sucker. Uterus joining male duct near anterodorsal portion of acetabulum. Eggs 92 to 111 by 58 to 67 microns.

Excretory vesicle terminating anteriorly at posterior edge of rear testis. Excretory pore subdorsal. Lymphatic system conspicuous with longitudinal vessels, 3 pairs in 1 specimen, 2 in another, running the length of the body; numerous branches in hindbody.

Discussion: This species differs from all others in *Apocreadium* and *Homalometron* in having a funnel-shaped oral sucker and a more foliate hindbody. The only other unspined *Apocreadium* is *A. longisinosum* Manter, 1937.

Three larger specimens of *A. cryptum* were donated by Dr. Robert Schroeder, who collected them from the pyloric caeca of *Haemulon sciurus* and *H. plumieri* caught near Lower Matecumbe Key, Florida. They differ from smaller individuals by having a more contracted pharynx and a greater number of eggs with a larger mean size, but the largest individual from *H. parrai* also has large eggs. A large specimen has one anomalous caecum which is completely interrupted to form a short branch joining the normal caecum and another portion with two blind ends extending the length of the vitellaria and lacking well-developed epithelium of normal caeca. No evidence of injury or degeneration as the cause of this abnormality was observed.

The name *cryptum* refers to the sometimes secret habitat of this species in a pyloric caecum.

Postporus epinepheli (Manter, 1947) Manter, 1949

Opisthoporus epinepheli Manter, 1947.
Postporus mycteropercae (Manter, 1947) Manter, 1949.

Host: *Mycteroperca bonaci* (1 of 3)*.
Site: Intestine.

Discussion: Siddiqi and Cable (1960: 305) reduced *Postporus mycteropercae* (Manter, 1947) to a synonym of *P. epi-*

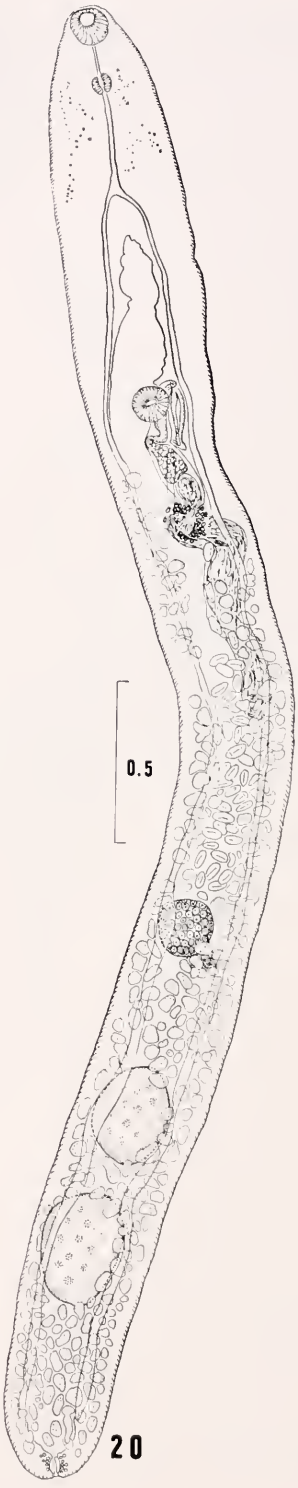

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Figure 20. *Neolepidapedon macrum*, holotype, ventral view.

nepheli. My three specimens are 2.8 to 3.1 long, have sucker ratios of 1:0.95 to 1.2 and have the prepharynx longer than the pharynx. They are like *P. mycteropercae*, except that the excretory vesicle reaches the pharyngeal level, thereby supporting the synonymy suggested by Drs. Siddiqi and Cable.

Neolepidapedon **macrum** sp. n.
Figure 20

Host: *Mycteroperca microlepis* (1 of 2), type host.
Site: Intestine.
Holotype: U. S. N. M. Helm. Coll. No. 71305.

Description (based on 1 specimen): Body elongate, 4.7 long by 0.42 wide. Entire cuticle spinose. Eyespot pigment present. Oral sucker slightly subterminal, 0.11 long by 0.12 wide. Acetabulum 0.11 long by 0.12 wide. Sucker ratio 1:1.1. Prepharynx 0.10 long. Pharynx 0.06 long by 0.06 wide. Esophagus 0.30 long. Intestinal bifurcation nearer oral sucker than acetabulum; caeca extending almost to posterior end of body.

Testes tandem, separated, smooth; anterior testis 0.30 long by 0.20 wide; posterior testis 0.35 by 0.25. Posttesticular space 0.54 long. Cirrus sac extending well posterior to acetabulum; containing small, oval, internal seminal vesicle, large conspicuous prostatic vesicle, and cirrus. External seminal vesicle tubular, sinuous, about twice length of cirrus sac. Prostatic cells few, free in parenchyma, mostly surrounding anterior portion of external seminal vesicle. Genital atrium small. Genital pore sinistral near anterolateral border of acetabulum.

Ovary entire, smooth, submedian, 0.19 long by 0.17 wide, anterior to and separated from anterior testis by about length of testis. Seminal receptacle postovarian. Uterus descending slightly posterior to ovary before extending anteriorly. Metraterm not as long as cirrus sac. Vitellaria extending from near posterior portion of cirrus sac to posterior end of body; confluent posterior to testes and between gonads, partially overlapping the gonads and excretory vesicle dorsally. Eggs 63 to 66 by 35 to 41 microns.

Excretory vesicle tubular, ending nearer intestinal bifurcation than acetabulum; sphincter well developed; pore terminal.

Discussion: Five other species of *Neolepidapedon* with an excretory vesicle extending almost to the intestinal bifurcation have been described. This species resembles *N. hypoplectri* Nahhas and Cable, 1964, and *N. mycteropercae* Siddiqi and Cable, 1960. It differs from *N. hypoplectri* in body shape, sucker ratio, number of prostatic cells, position of genital pore, and, probably, length of prepharynx. Nahhas and Cable (1964: 186) examined 55 additional specimens of *N. mycteropercae*, some from *Mycteroperca bonaci*, and discussed variability in the species. This specimen differs from *N. mycteropercae* in position of genital pore, anterior extent of vitellaria, and smaller sucker ratio.

Caballero *et al.* (1955:131-134) described and illustrated what they believed was *Lepidapedon elongatum* (Lebour, 1908) Nicoll, 1915, from a serranid host. If their species actually belongs in *Neolepidapedon* Manter, 1954, a genus erected for species without a membrane enclosing the prostatic cells, then we are probably dealing with the same species. My specimen differs from their description slightly in measurements and by possessing cuticular spines over the entire body, rather than just the anterior portion. Caballero *et al.* discussed the possibility of loss of some spines from their specimens during preparation of the material.

Bianium plicitum (Linton, 1928) Stunkard, 1931

Distomum sp. Linton, 1898 (from *Lagocephalus laevigatus*)—Linton 1905 (from *Syngnathus fuscus, Cynoscion regalis,* and *Sphaeroides maculatus*).
Psilostomum plicitum Linton, 1928.
Bianium concavum Stunkard, 1930.
Bianium adplicitum Manter, 1940.
Diploproctodaeum plicitum (Linton, 1928) Sogandares-Bernal and Hutton, 1959.

Hosts: *Sphaeroides spengleri* (1 of 2); *Sphaeroides testudineus* (4 of 5).
Site: Intestine.

Discussion: Manter (1947:279-281) discussed the variability in small specimens from Tortugas, Florida, medium-sized ones from Beaufort, North Carolina, and large individuals from Woods Hole and the Pa-

cific. My 10 mature specimens substantiate his data, as they also are intermediate as are those from Beaufort. They are 1.0 to 1.8 long with an immature individual reaching 1.2. The vitellaria never extend anterior to the acetabular level, and the acetabulum is larger than the oral sucker, except on the smallest and two immature specimens. This finding conflicts with Manter's suggestion that an increase in the size of the oral sucker may be correlated with an increase in body length.

Sogandares-Bernal and Hutton (1958) reviewed the status of *Bianium* Stunkard, 1930, and considered it a synonym of *Diploproctodaeum* LaRue, 1926. Travassos, Freitas, and Bührnheim (1965) erected *Amarocotyle* as a new genus for the species *A. simonei,* which possesses a small unlobed ovary and lacks an external seminal vesicle and is similar to *B. plicitum,* also from *Sphaeroides testudineus.* The authors separated three previously established species into *Diploproctodaeum* and *Bianium* and five others into *Diploporetta* Strand, 1942, and *Diplocreadium* Park, 1939. They did not include *B. vitellosum* (Sogandares-Bernal and Hutton, 1959) Gupta, 1968, and they accepted *B. lecanocephalum* Pérez Vigueras, 1955, which Sogandares-Bernal and Hutton (1958:566-567) considered a synonym of *D. haustrum* (MacCallum, 1918). Lamothe (1966:150-151) discussed the problem and recognized *B. plicitum, B. holocentri* (Yamaguti, 1942), *D. haustrum, D. cryptosoma* (Ozaki, 1928), *D. hemistroma* Ozaki, 1920, *D. tetraodontis* (Nagaty, 1956), and *D. vitellosum* Sogandares-Bernal and Hutton, 1959. He separated *Bianium* from *Diploproctodaeum* on the basis of including species with a more or less longer esophagus and ventrolateral folds which do not unite beyond the acetabulum. Gupta (1968), unaware of the works by Travassos *et al.* or Lamothe, considered *Diploproctodaeum* monospecific and separated *D. haustrum* from all the species of *Bianium* by the shape of the body, length of esophagus, position of genital pore, shape of ovary, and extent of vitellaria. He placed all the species discussed by Lamothe (except *D. haustrum*), *Diplocreadium koreanum* Park, 1939, and three new species all in the genus *Bianium.* Oshmarin, Mamaev, and Parukhin (1961) described three new related species from *Abalistes stellaris* in the Gulf of Tonkin, erecting a new genus for *Sphincteristomum acollum.* After considering their descriptions of the two new species of *Diploproctodaeum,* I still accept that genus as monospecific; therefore, *B. longipygum* and *B. macracetabulum* become new combinations.

All authors except Yamaguti (1958:134) and Gupta (1968:145) have apparently accepted *Diplocreadium* Park, 1939, until the presence of ani in *D. koreanum* is established.

I think that in order to better understand the validity of the above genera, additional specimens of *Diploproctodaeum haustrum, Diplocreadium koreanum, Amarocotyle simonei,* and *Sphincteristomum acollum* should be examined.

Bianium vitellosum (Sogandares-Bernal and Hutton, 1959) Gupta, 1968

Diploproctodaeum vitellosum Sogandares-Bernal and Hutton, 1959.

Host: *Chilomycterus schoepfi* (3 of 6)*.
Site: Intestine.

Discussion: Four specimens show considerable variation among themselves and with the description. The ovary is not necessarily sinistral or in contact with the anterior testis. In fact, the testes are diagonal to almost symmetrical, or overlapping medianly. As fixative was applied to one specimen, the testes changed from a tandem to almost symmetrical position. The right testis is consistently more ventral than the left. Contrary to the description by Sogandares-Bernal and Hutton, the cirrus sac in my specimens of *Bianium vitellosum* is not almost in contact with the ovary (as it is in my specimens of *B. plicitum*), and the external seminal vesicle does not overlap the ovary as it consistently does in my individuals of *B. plicitum.* The genital pore is located between the level of the posterior and middle of the pharynx, rather than at the anterior border of the acetabulum. Vitellaria always converge anterior to the acetabulum and usually reach the oral sucker, but extend only to the midpharyngeal level in one specimen.

The body length is 1.9 to 2.2, with sucker ratio of 1:1.0 to 1.2. There are a few delicate cuticular spines, primarily on the anterior portion of the body, and the excretory vesicle apparently extends almost to

the ovary. The ejaculatory duct is not sinuous. In life, *B. vitellosum* is orangeish, with what is normally the posterior portion of the body usually located behind and between the oral sucker and acetabulum, which, along with the anterior body folds, act as the holdfast organ. The free end may take numerous shapes, including elongate and caudate. In one living specimen the ani opened through two terminal protuberances.

Multitestis inconstans (Linton, 1905) Manter, 1931

Distomum inconstans Linton, 1905.

Host: *Chaetodipterus faber* (2 of 2).
Site: Intestine and pyloric caeca.

Crassicutis marina Manter, 1947

Host: *Eucinostomus gula* (1 of 3)*.
Site: Midintestine.

FAMILY OPISTHOLEBETIDAE Fukui, 1929

Pachycreadium crassigulum (Linton, 1910) Manter, 1954

Lebouria crassigula Linton, 1910.
Plagioporus crassigulus (Linton, 1910) Price, 1934.

Host: *Calamus bajonado* (1 of 1).
Site: Midintestine.

FAMILY OPECOELIDAE Ozaki, 1925

Apopodocotyle oscitans (Linton, 1910) Pritchard, 1966

Hamacreadium oscitans Linton, 1910.
Podocotyle breviformis Manter, 1940.
Pseudoplagioporus brevivitellus Siddiqi and Cable, 1960.

Hosts: *Anisotremus virginicus* (2 of 6); *Archosargus rhomboidalis* (2 of 5).
Site: Intestine and pyloric caeca.

Discussion: Pritchard (1966:166-167) erected *Apopodocotyle*, with *A. oscitans* as the type species, to include *Podocotyle*-like species having a postbifurcal, median, or submedian genital pore. The specimens from the intestine of *Anisotremus virginicus* are 0.9 and 1.3 long, whereas three specimens from the pyloric caeca of *Archosargus rhomboidalis* are 2.1 to 2.8 long. One of the large specimens is unusually gravid, with the uterus extending to the posterior end of the body. Partially-collapsed eggs are 49 to 56 by 35 to 40 microns.

Figure 21. *Hamacreadium confusum*, holotype, ventral view.

Hamacreadium mutabile Linton, 1910

Hosts: *Lutjanus griseus* (1 of 3); *Lutjanus synagris* (1 of 7).
Site: Pyloric caeca and stomach.

Hamacreadium **confusum** sp. n.
Figure 21

Hamacreadium mutabile Linton, 1910, of Siddiqi and Cable, 1960 (in part).

Host: *Ocyurus chrysurus* (1 of 5), type host.

Site: Intestine.
Holotype: U. S. N. M. Helm. Coll. No. 71306.

Description (based on 2 mature and 2 immature specimens from Biscayne Bay and Puerto Rico): Body elongate, rounded at both ends, usually with a slight constriction at acetabular level, 1.2 to 2.2 long by 0.45 to 0.71 wide at level of anterior portion of acetabulum; hindbody slightly wider. Oral sucker subterminal, 0.14 to 0.17 long by 0.14 to 0.18 wide. Acetabulum 0.23 to 0.26 long by 0.22 to 0.29 wide, at or near equatorial level. Sucker ratio 1:1.4 to 1.7. Forebody 36 to 44% of body length. Prepharynx 0.02 to 0.05 long. Pharynx 0.06 to 0.12 long by 0.08 to 0.11 wide. Esophagus 0.06 to 0.16 long. Intestinal bifurcation usually nearer oral sucker than acetabulum. Caeca epithelial, terminating near posterior end.

Testes slightly irregular, diagonal, contiguous or separated; left testis anterior, 0.20 to 0.28 long by 0.17 to 0.19 wide; right testis 0.19 to 0.33 by 0.17 to 0.28. Posttesticular space 9 to 13% of body length. Genital pore sinistral, close to or ventral to caecum, about midway between intestinal bifurcation and acetabulum. Cirrus sac arcuate, terminating posteriorly at anterior border of acetabulum; containing large, folded seminal vesicle, short tubular prostatic vesicle, prostatic cells, and short muscular cirrus.

Ovary dextral to median, lobed; usually 6 secondary lobes. Seminal receptacle in contact with ovary. Vitelline follicles extending from midesophageal or postpharyngeal level to posterior end, slightly confluent anteriorly. Uterus preovarian. Eggs thin-shelled, 72 to 85 by 43 to 49 microns.

Excretory vesicle extending to ovarian zone; pore terminal, sphincter present.

Discussion: One specimen with two eggs and one with none, both from *Ocyurus chrysurus* and slightly contracted, were lent by Dr. R. M. Cable and used in the above description. Of the four specimens, the smallest contains two eggs and all have well-developed organs, so the immature specimens are included in the description. All are similar to *Hamacreadium mutabile* and *Cainocreadium gulella* from related hosts. In fact, Siddiqi and Cable (1960:297) identified their specimens as *H. mutabile*, but they differ from that species in that the excretory vesicle extends to the ovarian level only, rather than beyond the acetabulum. Yamaguti (1934:310-311) mentioned the taxonomic importance of the extent of the vesicle in *H. mutabile*. Because *C. gulella* has a median genital pore, Durio and Manter (1968:751) transferred that species from *Hamacreadium* to *Cainocreadium*. The present species is the only one in *Hamacreadium* reported to possess a short excretory vesicle. Of the several species for which the extent of the vesicle is unknown, *H. confusum* is distinguished from *H. diacopae* Nagaty and Abdel Aal, 1962, and *H. leiperi* Gupta, 1956, by the lobated ovary; from *H. balistis* Nagaty and Abdel Aal, 1962 (originally *H. balistesi*), by the uninterrupted vitellaria; and from *H. morgani* Baz, 1946, primarily by the size. The latter is 5.7 to 7.3 long and probably a synonym of *H. mutabile*.

Helicometra torta Linton, 1910

Helicometra pretiosa Bravo-Hollis and Manter, 1957 (new synonym).

Hosts: *Epinephelus adscensionis* (1 of 1)*; *Epinephelus striatus* (1 of 2).
Site: Intestine and pyloric caeca.

Discussion: Three specimens from the pyloric caeca of *Epinephelus striatus* have cirrus sacs that extend near or past the posterior border of the acetabulum, gonads close together, and lobed testes. Specimens from the midintestine of *E. adscensionis* have shorter extending cirrus sacs and rounded, separated testes. The excretory vesicle projects slightly past the ovary, depending on the contraction of the body. Because of the variation among my specimens, in addition to that found by Siddiqi and Cable (1960:300), I consider *Helicometra pretiosa* Bravo-Hollis and Manter, 1957, a synonym of *H. torta*.

Helicometrina execta (Linton, 1910) comb. n.

Helicometra execta Linton, 1910.
Helicometrina parva Manter, 1933 (new synonym).
Helicometrina trachinoti Siddiqi and Cable, 1960 (new synonym).

Hosts: *Anisotremus virginicus* (2 of 6)*; *Bathygobius soporator* (2 of 9); *Blennius cristatus* (1 of 6)*; *Halichoeres bivittatus*

(10 of 11); *Halichoeres pictus* (2 of 2); *Halichoeres radiatus* (7 of 8); *Labrisomus kalisherae* (2 of 2)*; *Trachinotus falcatus* (3 of 6)*.

Site: Rectum and intestine.

Discussion: I believe *Helicometrina parva* Manter, 1933, to be synonymous with *Helicometra execta* Linton, 1910, although *H. execta* is to be transferred to the genus *Helicometrina* as *H. execta* (Linton, 1910). When two testes are present, they are not tandem as they almost always are in species of *Helicometra.* There is intergradation of characters previously used to differentiate the two forms. Collections of 26, 15, and 14 mature specimens from *Halichoeres radiatus, H. bivittatus* and *H. pictus* respectively contain individuals with from none to five testes. Sucker ratios range from 1:1.6 to 2.1, and the acetabulum is situated anywhere from the midlevel to just within the anterior 1/3 of the body. The body ranges from 0.86 to 2.07 in length, and the cirrus sac from pre- to midacetabular in posterior extent. The ovary has three to many lobes, with secondary lobing predominant. The characters originally defined as characterizing *H. parva* are not constant, and Manter (1933a:179) apparently was correct in implying that *H. parva* may be a variation of *H. execta.*

Eleven additional specimens from two *H. bivittatus* and one from *H. pictus* have nine testes, sucker ratios of 1:1.8 to 2.8, and further agree with my individuals of *H. execta* in having few ovarian lobes and the cirrus sac extending to midacetabulum. They also resemble *H. trachinoti* Siddiqi and Cable, 1960. Only worms with 9 testes were in the two *H. bivittatus,* whereas the specimen from *H. pictus* was accompanied by several others with fewer testes.

Five specimens from *Trachinotus falcatus,* four from *Anisotremus virginicus,* and five from *Labrisomus kalisherae* were much like *H. trachinoti* with sucker ratios of 1:1.8 to 2.5. In specimens from all hosts, the location of the genital pore varies among positions anterior, posterior, or directly ventral to the intestinal bifurcation. The cirrus sac may be on either the right or left of the acetabulum and varies in extent from the anterior margin to the midlevel of the acetabulum. There is at least one testis short of the predominant nine in some specimens from *T. falcatus* and *A. virginicus,* and *L. kalisherae* contained individuals with four, seven, eight, and nine testes. Two worms from *Bathygobius soporator* and one from *Blennius cristatus* have nine testes and compare well with others having that number. Thus, from the morphological variation and the low host specificity recorded for *H. execta* (Manter, 1933a:170), I also consider *H. trachinoti* synonymous with *H. execta.*

A few specimens from *Halichoeres radiatus* have poorly-formed eggs.

Helicometrina mirzai Siddiqi and Cable, 1960

Hosts: *Labrisomus nuchipinnis* (1 of 1)*; *Ogcocephalus cubifrons* (1 of 2)*; *Opsanus beta* (3 of 6)*.

Site: Intestine and rectum.

Discussion: Twenty specimens from *Labrisomus nuchipinnis* 1.0 to 1.7 long have nine testes and sucker ratios of 1:1.9 to 2.2. The locations of the genital pore and the acetabulum vary as in *Helicometrina execta,* but most specimens differ from *H. execta* in having a long interruption of vitellaria at the level of the acetabulum. In a few specimens, the interruption is short or unilateral. Four individuals from *Ogcocephalus cubifrons* compare well with those from *L. nuchipinnis.*

I consider some specimens from *Opsanus beta* to be *H. mirzai* and designate others from that host as *H. nimia* because there is extensive secondary lobing of the ovary. Some confusion exists because both *H. mirzai* and *H. nimia* are present in one individual of *O. beta,* and specimens with narrow interruptions of the vitellaria and weak secondary lobing of the ovary are present in another. Additional collections may show the two to be the same species.

Helicometrina nimia Linton, 1910

Helicometrina orientalis Srivastava, 1936.
Helicometrina elongata Noble and Park, 1937.

Hosts: *Lutjanus apodus* (1 of 3); *Lutjanus mahogoni* (1 of 2)*; *Ocyurus chrysurus* (1 of 5); *Opsanus beta* (2 of 6)*; *Scorpaena grandicornis* (1 of 2)*.

Site: Pyloric caeca, intestine, and rectum.

Discussion: Manter (1933a:176) reported

egg measurements for *Helicometrina nimia* from the Tortugas of 40 to 50 by 22 to 30 microns. In the present study, measurements of eggs from individuals from all hosts are 53 to 68 by 25 to 34 microns. An atypical specimen from *Scorpaena grandicornis* is 4.1 long and has only three testes.

Deelman (1960:13) examined several hundred specimens from a single species of host from one locality, and reduced *H. orientalis* and *H. elongata* to synonymy with *H. nimia.*

Manteriella crassa (Manter, 1947) Yamaguti, 1958

Horatrema crassum Manter, 1947.

Host: *Equetus acuminatus* (3 of 3).
Site: Intestine and bile duct.

Discussion: I am following Mehra (1966: 23) and accepting the genus *Manteriella.* One host 9 cm long had six specimens in its bile duct in addition to 14 in its intestine.

The host for *M. crassa* and *Pseudopecoeloides equesi* is the bold-striped island-species of *Equetus* common in the Florida keys. It is commonly referred to as *E. pulcher* and is the species examined by Nahhas and Cable (1964).

Pseudopecoeloides equesi Manter, 1947

Host: *Equetus acuminatus* (3 of 3).
Site: Intestine.

Discussion: The acetabulum may be larger than the oral sucker rather than smaller as described by Manter (1947:291). The cuticle, especially on and near the acetabular stalk and the terminal portion of the body, is ringed with minute striae bearing numerous pointed projections.

Pseudopecoelus scorpaenae (Manter, 1947) comb. n.

Neopecoelus scorpaenae Manter, 1947.

Host: *Scorpaena plumieri* (2 of 4).
Site: Posterior intestine and rectum.

Discussion: Seven wholemounts agree fairly well with the description of *Neopecoelus scorpaenae.* They are 1.3 to 2.0 long by 0.33 to 0.51 wide, sometimes widest at the acetabular level. The forebody is 17 to 21% of body length. The oral sucker is 0.09 to 0.12 long by 0.09 to 0.10 wide and the acetabulum is 0.16 to 0.20 by 0.22 to 0.28, with sucker ratios of 1:2.5 to 2.8. Eggs are partially collapsed and measure 49 to 54 by 30 to 34 microns. The genital pore is usually near the anrerior level of the pharynx. The seminal vesicle passes to the left, right, or dorsal to the acetabulum before becoming strongly sinuous posterior to that sucker. Vitellaria extend from the middle of the acetabulum in one specimen, the posterior edge of the acetabulum in others. Temporary folds on the acetabulum of one specimen appear as but are not true papillae. The excretory vesicle extends a short distance anterior to the ovary.

Serial sagittal sections of a specimen did not reveal ani. Manter (1947:294) stated that they "are inconspicuous in preserved specimens but were clearly observed in living specimens." Nahhas and Cable (1964: 195) could not observe ani in either living or preserved material. Their absence places this species in the genus *Pseudopecoelus* where it differs from most species in lacking a lobed ovary. It is very similar, if not identical, to *P. barkeri* Hanson, 1950, from squirrel fishes. The posttesticular space in *P. scorpaenae* is slightly longer. There is apparently much variation in *P. barkeri.* Siddiqi and Cable (1960, Figure 93) illustrated a specimen with a sucker ratio of 1:1.6 and widely-interrupted vitellaria. Nahhas and Cable (1964:196) have specimens that differ from *P. tortugae* seemingly in size of eggs only. *Pseudopecoelus scorpaenae* differs from *P. elongatus* (Yamaguti, 1938) Von Wicklen, 1946, in anterior extent of vitellaria, shape and site of ovary, and size of pharynx; and from *P. manteri* Sogandares-Bernal and Hutton, 1959, in sucker ratio, anterior extent of vitellaria, and, probably, position of testes.

Because *N. scorpaenae* is the type species of *Neopecoelus* Manter, 1947, and I consider it a synonym of *P. scorpaenae, Neopecoelus* becomes a synonym of *Pseudopecoelus* Von Wicklen, 1946, and hence unavailable, requiring the erection of a new genus for *N. holocentri* Manter, 1947.

Apertile gen. n.

Generic diagnosis: Body elongate, aspinose. Acetabulum without papillae. Pharynx large. Each caecum with anus. Testes lobed or not, tandem. Genital pore sinistral, at pharyngeal level. Cirrus sac absent, seminal

vesicle tubular, extending posterior to acetabulum. Ovary lobed or not. Seminal receptacle absent. Uterus preovarian. Metraterm present. Vitellaria from acetabular level to posterior end of body. Excretory vesicle short. Parasitic in intestines of marine fishes. Type species: *Apertile holocentri* (Manter, 1947) comb. n.

Discussion: *Apertile* differs from *Pseudopecoelus* by having separate ani. *Neohelicometra* Siddiqi and Cable, 1960, also has separate ani but differs from *Apertile* primarily in having a funnel-shaped oral sucker, a seminal receptacle, and filamented eggs. The significance of ani in some opecoelids is questionable. Sogandares-Bernal and Hutton (1959c:341) showed that in *Opecoelides fimbriatus* the ability to see ani or a uroproct depends on the contraction of the body.

The name *Apertile* is from *apertum* (opened) and *ile* (intestine), and refers to the ani.

Opegaster **pritchardae** sp. n.
Figure 22

Host: *Bathygobius soporator* (1 of 9), type host.

Site: Rectum.

Holotype: U. S. N. M. Helm. Coll. No. 71307, paratype: No. 71369.

Description (based on 11 wholemounts and 1 sectioned specimen from Biscayne Bay and Florida keys): Body elongate, 1.0 to 1.4 long by 0.32 to 0.47 wide, tapering slightly toward ends, decidedly pointed posteriorly in living specimens; a slight constriction at acetabular level. Oral sucker 0.09 to 0.13 long by 0.09 to 0.15 wide. Acetabulum 0.18 to 0.25 by 0.19 to 0.26, with thickened anterior and posterior lips; papillae lacking. Sucker ratio 1:1.6 to 2.0. Forebody 30 to 38% of body length. Prepharynx short, pharynx 0.06 to 0.08 long by 0.05 to 0.08 wide. Esophagus shorter than, to over twice as long as, pharynx. Intestinal bifurcation usually closer to acetabulum than pharynx. Caeca uniting posteriorly and opening ventrally at an inconspicuous common anus.

Gonads postequatorial. Testes tandem, contiguous, slightly irregular; anterior testis 0.10 to 0.18 long by 0.20 to 0.26 wide; posterior testis 0.13 to 0.23 by 0.16 to 0.23. Posttesticular space 9 to 14% of body length. Genital pore inconspicuous, sinistral, slightly posterior to pharyngeal level. Cirrus sac short, slender; containing reduced prostatic vesicle and cirrus. Seminal vesicle external, saccate, extending to or overlapping acetabulum anteriorly; surrounded by few prostatic cells.

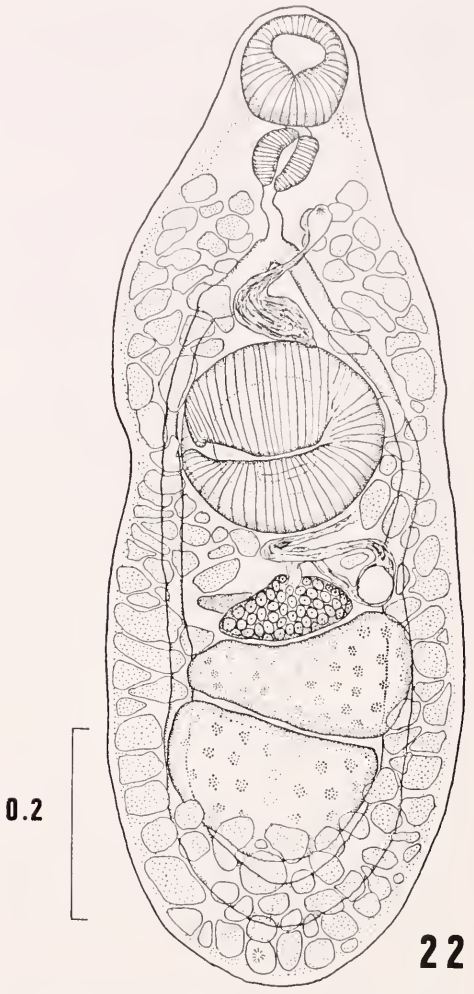

Figure 22. *Opegaster pritchardae*, holotype, ventral view.

Ovary slightly irregular, 0.07 to 0.11 long by 0.11 to 0.20 wide, median or dextral, touching anterior testis. One ovary sinistral rather than dextral, with genital pore in that atypical specimen at midpharyngeal level. Seminal receptacle lacking. Laurer's canal present. Vitellaria from anterior esophageal level to posterior end of body, con-

fluent in forebody and posttesticular space. Metraterm weakly developed, extending to level of acetabulum. Eggs 54 to 64 by 31 to 39 microns.

Excretory vesicle I-shaped, extending to ovarian level. Excretory pore terminal or subterminal.

Discussion: Mr. Richard Heard provided eight mature specimens of *Opegaster pritchardae* which were collected from the intestine of *Bathygobius soporator* at Molasses Key, Florida. They agree in most respects with individuals from Biscayne Bay and are used in the description.

The species differs from all others in the genus *Opegaster* Ozaki, 1928, except *O. caulopsettae* Manter, 1954, by lacking acetabular papillae. The anterior and posterior lips are too large and muscular to be papillae as in many opecoelids and not as muscular as the lips in *Labrifer* Yamaguti, 1936. The caeca in *O. caulopsettae* are described as "seemingly uniting near posterior end of body and opening dorsally through an anus just anterior to the excretory pore near posterior end of body" (Manter, 1954:503). In my specimens the anus is ventral, the gonads are not lobed, the seminal vesicle does not extend past the acetabulum, and the posttesticular space is much shorter. They are most like *O. gobii* Manter, 1954, which has small acetabular papillae which sometimes are not evident (Manter, 1954: 503). *Opegaster pritchardae* is most easily distinguished from that species by the shorter posttesticular space.

This species is named in honor of Mrs. Mary Hanson Pritchard, in recognition of her contributions to the field of trematodology.

Genitocotyle cablei Nahhas and Short, 1965

Host: *Hippocampus erectus* (3 of 4)*.
Site: Intestine.

Discussion: Three specimens from *Hippocampus erectus* are identified as *Genitocotyle cablei* and provide the following measurements which extend the ranges of those in the original description: length, 1.4 to 3.4; width, 0.36 to 0.66; diameter of oral sucker, 0.13 to 0.21; diameter of acetabulum, 0.20 to 0.29; sucker ratio, 1:1.4 to 1.5; forebody, 20 to 29% of body length; pharynx, 0.11 to 0.18 long by 0.10 to 0.16 wide; esophagus longer or shorter than

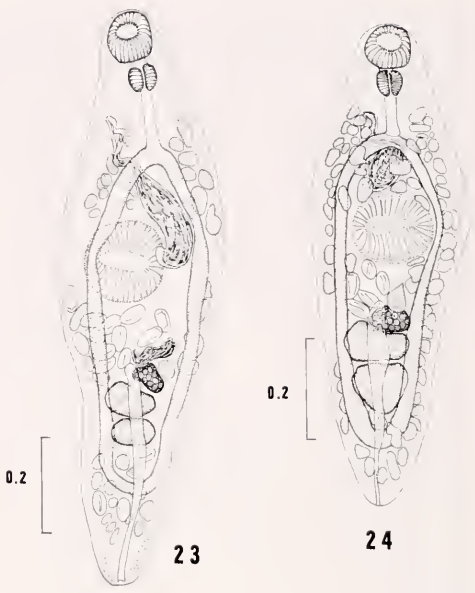

Figure 23. *Nicolla halichoeri*, holotype, dorsal view. Figure 24. *Nicolla halichoeri*, dorsal view.

pharynx. Diameters of anterior testis 0.21 to 0.37, posterior testis 0.19 to 0.45, ovary 0.17 to 0.25. Eggs, 46 to 48 by 19 to 37 microns. The anterior extent of the excretory vesicle is not visible.

Genitocotyle cablei was previously known from *Ancylopsetta quadrocellata* in Apalachee Bay, Gulf of Mexico (Nahhas and Short, 1965:42).

Nicolla **halichoeri** sp. n.
Figures 23 and 24

Hosts: *Halichoeres bivittatus* (3 of 11); *Halichoeres radiatus* (3 of 8), type host.
Site: Intestine.
Holotype: U. S. N. M. Helm. Coll. 71308, paratype: No. 71370.

Description (based on 14 wholemounts and 1 sectioned specimen): Body spindle-shaped, smooth, 0.7 to 1.2 long by 0.25 to 0.32 wide; widest at acetabular level. Oral sucker 0.07 to 0.10 long by 0.07 to 0.10 wide. Acetabulum slightly preequatorial, 0.11 to 0.17 by 0.12 to 0.19. Sucker ratio 1:1.8 to 2.1. Forebody 32 to 38% of body length. Prepharynx usually about ½ as long as pharynx. Pharynx 0.05 to 0.06 long by 0.04 to 0.06 wide. Esophagus 1 to 2 times as long as pharynx. Intestinal bifurcation ap-

proximately midway between acetabulum and pharynx. Caeca united slightly posterior to testes.

Testes smooth to somewhat irregular, tandem, contiguous in all but one atypical specimen with ovary between them; anterior testis 0.05 to 0.10 long by 0.08 to 0.18 wide; posterior testis 0.07 to 0.12 by 0.09 to 0.15. Posttesticular space 18 to 23% of body length. Cirrus sac thin-walled, claviform; touching anterior border of acetabulum dextrally, sinistrally, or medially; containing large saccate seminal vesicle, short cirrus. Prostatic cells few, free in parenchyma. Genital pore sinistral at esophageal level.

Ovary subglobular, 0.03 to 0.07 long by 0.05 to 0.09 wide, either median or dextral, in contact with anterior testis. Seminal receptacle usually indistinct, proximal coils of uterus full of sperm. Laurer's canal present. Vitelline follicles well developed, from esophageal level to near posterior end of body, confluent anteriorly and posteriorly, one or more follicles usually between posterior testis and caecal loop. Uterus may extend posteriorly beyond caecal loop. Eggs partially collapsed, 49 to 62 by 26 to 34 microns.

Excretory vesicle I-shaped, extending to ovarian level; pore terminal.

Discussion: This species is similar to *Nicolla gallica* (Dollfus, 1941) Dollfus, 1959, in length of the body and in extent of the excretory vesicle. It differs from that species in having a uterus which may extend posterior to the ovary. The uterus also extends posteriorly in *N. wisniewskii* (Ślusarski, 1958), although the excretory vesicle in that species extends to near the posterior margin of the rear testis *Nicolla halichoeri* is probably the same as that Nahhas and Cable (1964:198) described and illustrated as *Coitocaecum* sp., in which the uterus extended slightly posterior to the ovary and a seminal receptacle was lacking.

Nicolla sp.
Figure 25

Host: *Halichoeres pictus* (2 of 2).
Site: Intestine.
Specimen deposited: U. S. N. M. Helm. Coll. No. 71309.

Discussion: Five specimens of *Nicolla* sp. 0.7 to 1.2 long by 0.25 to 0.32 wide with a sucker ratio 1:1.8 to 2.1, an esophagus shorter than the pharynx, the rear margin of the posterior testis overlapping the united caeca, and a small prostatic vesicle appear to represent a new species. These specimens, however, may be *N. halichoeri* in an unsatisfactory host-parasite relationship since the vitellaria in three of the specimens are poorly formed and all the specimens are from a different species of wrasse than is *N. halichoeri*. *Nicolla* sp. appears similar to *N. extrema* Travassos, Freitas, and Bührnheim, 1965, in the appearance of the testes. It differs from *N. extrema* in length of the body and in the sucker ratio.

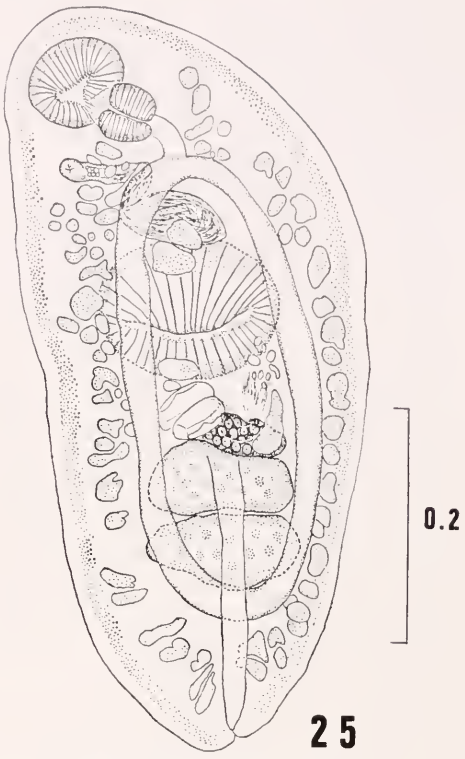

Figure 25. *Nicolla* sp., dorsal view.

FAMILY GORGODERIDAE Looss, 1901

Xystretrum solidum Linton, 1910

"Trematode ailied with *Phyllodistomum*" of Linton, 1907.
Xystretrum papillosum Linton, 1910.
Catoptroides aluterae MacCallum, 1917.
Catoptroides magnum MacCallum, 1917.
Macia pulchra Travassos, 1921.

Xystretrum pulchrum (Travassos, 1921) Manter, 1947.

Hosts: *Balistes capriscus* (1 of 4); *Monacanthus hispidus* (1 of 6)*; *Sphaeroides testudineus* (5 of 6).

Site: Urinary bladder.

Discussion: Before Siddiqi and Cable (1960:282-283) reduced *Xystretrum pulchrum* to synonymy with *X. solidum*, the two were separated mainly by a sucker ratio of 1:1.5 or less in *X. pulchrum*, and a ratio of 1:1.5 or more with an abrupt widening of the hindbody in *X. solidum* (Manter, 1947:329-331).

Ten specimens from *Sphaeroides testudineus*, with varying degrees of widening of the hindbody, have sucker ratios of 1:1.1 to 1.8; the lower ratios are from small worms and two of the three with larger ratios are poor preparations. The sucker ratio of seven specimens from *Monacanthus hispidus* is 1:1.3 to 1.6 and 1:1.3 in one worm from *Balistes capriscus*. Manter (1947) reported *X. solidum* from *B. capriscus* and *X. pulchrum* from *Sphaeroides splengeri*.

FAMILY ZOOGONIDAE Odhner, 1911

Diplangus paxillus Linton, 1910

Hosts: *Anisotremus virginicus* (2 of 6); *Haemulon carbonarium* (1 of 1)*; *Haemulon parrai* (5 of 7); *Haemulon sciurus* (3 of 6).

Site: Rectum and posterior intestine.

Discussion: There is much overlap of characteristics of *Diplangus paxillus* and *D. parvus* Manter, 1947. The length of *D. parvus*, 0.46 to 1.05, overlaps that of *D. paxillus*, 0.63 to 1.67. Also, testes may be tandem to diagonal in both species, and the size, shape, and number of coils in the seminal vesicle are not constant in either species. The posterior end of *D. parvus* is usually broadly rounded but may be pointed, whereas the generally pointed posterior end of *D. paxillus* may appear rounded. In both species, vitelline follicles vary in number and are situated between the anterior border of the acetabulum and that of the posterior testis, although they are usually restricted to the acetabular zone in *D. parvus*. The acetabulum in both species is protrusible and usually preequatorial. Extent of the caeca varies between the posterior edge of the acetabulum and the middle of the post-testicular space, with the caeca of *D. parvus* usually shorter. In that species, the excretory vesicle reaches levels ranging from the middle of the posterior testis to the acetabulum. In *D. paxillus*, the vesicle ends near the ovarian level, although Manter (1947, Figure 71) illustrated it as being entirely posttesticular. The eggs of *D. parvus* are 26 to 36 by 13 to 19 microns and those in *D. paxillus* 27 to 39 by 14 to 17 microns.

Diplangus paxillus can be separated from *D. parvus* by having a sucker ratio of 1:1.2 to 1.7, as compared with 1:2.1 to 2.6. Also, *D. paxillus* occurs in the rectum or posterior intestine of the host, and *D. parvus* in or near the pyloric caeca.

Diplangus parvus Manter, 1947

Bilecithaster ovalis Siddiqi and Cable, 1960 (new synonym).

Hosts: *Anisotremus virginicus* (3 of 6)*; *Haemulon carbonarium* (1 of 1); *Haemulon parrai* (2 of 7)*; *Haemulon plumieri* (1 of 5); *Haemulon sciurus* (5 of 6).

Site: Pyloric caeca and anterior intestine.

Discussion: I believe *Bilecithaster ovalis* Siddiqi and Cable, 1960, is a synonym of *Diplangus parvus*, and therefore *Bilecithaster* Siddiqi and Cable, 1960, a synonym of *Diplangus* Linton, 1910. *Bilecithaster ovalis* was apparently placed in the family Hemiuridae because the excretory arms seemed to unite at a level dorsal to the oral sucker. With the exception of that feature, *B. ovalis* fits the description of *D. parvus*, which is found in the same site, within the same host, from Tortugas, Florida, and Jamaica.

Diphtherostomum anisotremi Nahhas and Cable, 1964

Hosts: *Anisotremus virginicus* (4 of 6); *Haemulon plumieri* (3 of 5)*; *Haemulon sciurus* (5 of 6).

Site: Rectum.

Discussion: Nine specimens from the type host, *Anisotremus virginicus*, measure 0.53 to 1.08, have sucker ratios of 1:1.5 to 2.1, with the length of the esophagus three to eight times that of the pharynx, and the cirrus sac three to four times as long as wide. Specimens from *Haemulon sciurus* and *H. plumieri* have the same features except that some have an even larger esophagus-to-pharynx length ratio.

In the original description, *Diphtherostomum anisotremi* was differentiated from *D. americanum* by having an esophagus at least three times as long as the pharynx rather than being about the same length, and a cirrus sac about four times as long as wide instead of the width being ½ to ¾ the length.

Diphtherostomum americanum
Manter, 1947

Hosts: *Archosargus rhomboidalis* (2 of 5)*; *Eupomacentrus leucostictus* (1 of 6)*; *Lagodon rhomboides* (1 of 5).
Site: Rectum and posterior intestine.

Discussion: Sogandares-Bernal and Hutton (1959c:342-343) identified trematodes from *Gobiosoma robustum, Lagodon rhomboides,* and *Opsanus beta* as *D. americanum.* Their illustration shows a short esophagus and a long, thin cirrus sac as do my specimens. In fixed ones, the length of the esophagus is 1.0 to 2.1 times the length of the pharynx; in a living specimen from *Archosargus rhomboidalis* it varied from slightly longer to 3.5 times longer than the pharynx. An egg released from that worm was 54 by 26 microns compared to 30 to 45 by 13 to 17 microns after the specimen was mounted. All my specimens identified as *D. anisotremi* or *D. americanum* have a completely spinose cuticle, an observable seminal receptacle, and variations in the positions of the gonads as reported by Sogandares-Bernal and Hutton (1959c:343). Apparently the only difference between the two species is the length of the variable esophagus. Another closely related, if not identical, species is *D. macrosaccum* Montgomery, 1957, which is completely covered with spines, has a short esophagus, and has a cirrus sac about nine times longer than it is wide. This trematode is found in *Neoclinus uninotatus,* a blenny from California.

Diphtherostomum **albulae** sp. n.
Figure 26

Host: *Albula vulpes* (4 of 7), type host.
Site: Intestine and pyloric caeca.
Holotype: U. S. N. M. Helm. Coll. No. 71310, paratype: No. 71371.

Description (based on 13 specimens, 4 with newly-formed eggs): Body small, plump, tapered at ends, 0.43 to 0.73 long by 0.19 to 0.34 wide. Cuticle completely spinose. Oral sucker terminal or slightly subterminal, 0.08 to 0.10 long by 0.10 to 0.13 wide. Acetabulum weakly developed, without lip-like thickening, 0.08 to 0.11 by 0.08 to 0.11. Sucker ratio 1:0.75 to 0.92. Forebody 38 to 57% of body length. Prepharynx very short. Pharynx 0.03 to 0.04 long by 0.03 to 0.04 wide. Esophagus 2 to 3 times longer than pharynx. Intestinal bifurcation approximately midway between suckers. Caeca short, ending just anterior to or within acetabular zone.

Testes roughly symmetrical, at or slightly anterior to level of acetabulum; left testis 0.08 to 0.12 long by 0.05 to 0.09 wide; right testis 0.09 to 0.13 by 0.05 to 0.10.

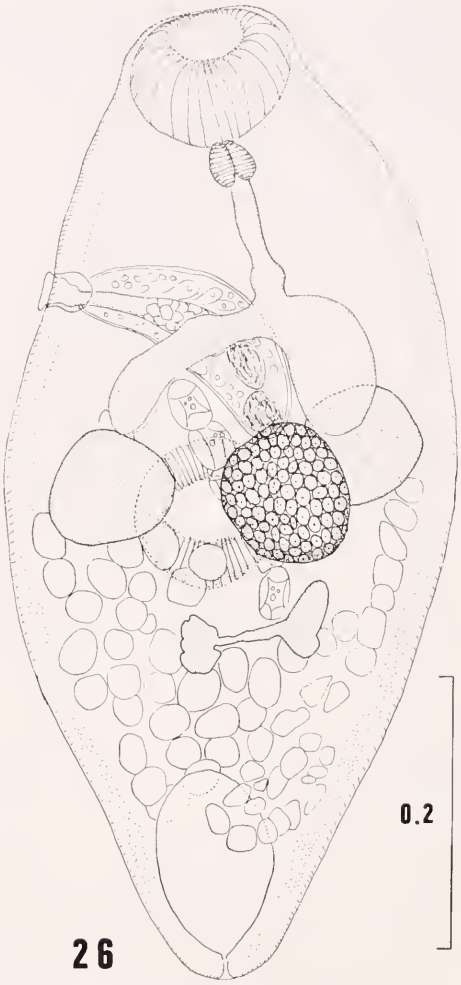

Figure 26. *Diphtherostomum albulae,* holotype, dorsal view.

Genital pore at or near sinistral margin of body, at level of or slightly anterior to intestinal bifurcation. Cirrus sac thick-walled, arcuate to straight, 0.14 to 0.21 long by 0.06 to 0.09 wide, usually ending at anterior border of acetabulum; containing bipartite seminal vesicle, wide prostatic vesicle, prostatic cells, and short, unarmed cirrus.

Ovary smooth, 0.07 to 0.11 long by 0.07 to 0.11 wide, dorsal to acetabulum, at or slightly posterior to level of testes, usually close to right testis. Seminal receptacle not observed. Uterus filling most of body posterior to testes except extreme posterior region. Metraterm weak. Vitellaria 2 small masses near posterior portion of ovary. Eggs extremely thin-shelled, 25 to 42 by 16 to 31 microns, when not compressed.

Excretory vesicle short, saccate. Excretory pore at or near posterior end.

Discussion: This species differs from others in the genus *Diphtherostomum* by lacking thickened acetabular margins and lip-like folds of the body overlapping the acetabulum, and by having an oral sucker larger than the acetabulum. In *D. microacetabulum* Schulman-Albowa, 1952, the suckers are about equal in size, the esophagus is shorter, the cirrus sac has a thinner wall than in *D. albulae,* and an obvious seminal receptacle is present.

Steganoderma nitens
(Linton, 1898) Manter, 1947

Distomum nitens Linton, 1898.
Lecithostaphylus nitens (Linton, 1898) Linton, 1940.
Steganoderma elongatum Manter, 1947.

Host: *Tylosurus crocodilus* (1 of 7)*.
Site: Intestine

Discussion: Because of overlapping characters, Nahhas and Cable (1964:199) reduced *S. elongatum* to synonymy with *S. nitens.* I find that the position of the ovary varies from midway between the testes and acetabulum to near that sucker, and the genital pore is sometimes almost marginal. In contrast to Nahhas and Cable's specimens, only three of my 48 have vitellaria that do not lie posterior to the testes. In those, the follicles, on one side only, end beyond the midlevel of the testes. The eggs measure 28 to 36 by 16 to 20 microns.

The host, *Tylosurus crocodilus* (Peron and Lesueur), was identified by Mr. F. H. Berry. This fish is separate from, but sometimes identified as, *T. acus.*

FAMILY MONORCHIIDAE Odhner, 1911

Genolopa ampullacea Linton, 1910

Genolopa longicaudata Siddiqi and Cable, 1960.

Hosts: *Anisotremus virginicus* (4 of 6)*; *Haemulon aurolineatum* (5 of 7)*; *Haemulon flavolineatum* (2 of 2); *Haemulon parrai* (7 of 7); *Haemulon plumieri* (3 of 5); *Haemulon sciurus* (6 of 6).
Site: Pyloric caeca and anterior intestine.

Discussion: The considerable range in characteristics of this species has been noted by Manter (1942:351), Nahhas and Cable (1964:201), and others. The eggs are 13 to 20 by 9 to 13 microns and usually smaller than those described by Linton (1910:78) and Manter (1942:351). The atrial spines are up to 49 microns long, the ovary is subglobular to distinctly trilobed, and the oral sucker may be pyriform in shape.

Lasiotocus longovatus
(Hopkins, 1941) Thomas, 1959

Genolopa longovatum Hopkins, 1941.
Proctotrema longovatum (Hopkins, 1941) Manter, 1942.

Hosts: *Anisotremus virginicus* (2 of 6)*; *Haemulon aurolineatum* (1 of 7); *Haemulon parrai* (1 of 7)*; *Haemulon sciurus* (2 of 6); *Orthopristis chrysopterus* (3 of 4).
Site: Pyloric caeca and intestine.

Discussion: There is considerable variation in this species. The caeca may end at the testicular level rather than somewhat past it, the testis may be well removed from the acetabulum, and the cirrus sac often extends beyond the acetabulum. The body is characteristically urn-shaped as originally described but exceptions occur (Nahhas and Cable, 1964:201).

Whether various species of monorchiids should be in the genus *Proctotrema* or *Lasiotocus* has been discussed by Manter and Pritchard (1961:483-484) and Nahhas and Cable (1964:200). I am following Bartoli and Prévot (1966:406) who transferred to the genus *Lasiotocus* all species previously referred to as *Proctotrema* except *P. bacilliovatum.*

Lasiotocus truncatus (Linton, 1910) Thomas, 1959

Genolopa truncatum Linton, 1910.
Proctotrema truncatum (Linton, 1910) Manter, 1940.

Hosts: *Haemulon flavolineatum* (2 of 2); *Haemulon plumieri* (4 of 5); *Haemulon sciurus* (5 of 6).
Site: Pyloric caeca.

Lasiotocus longicaecum (Manter, 1940) Yamaguti, 1954

Proctotrema longicaecum Manter, 1940.

Host: *Anisotremus virginicus* (3 of 6).
Site: Rectum.

Lasiotocus **mugilis** sp. n.
Figures 27, 28, and 29

Host: *Mugil cephalus* (1 of 3), type host.
Site: Intestine.
Holotype: U. S. N. M. Helm. Coll. No. 71311, paratype: No. 71372.

Description (based on 5 wholemounts): Body delicate, 0.8 to 1.3 long by 0.24 to 0.38 wide; forebody narrow; posterior end bluntly rounded. Cuticle spined. Eyespots lacking. Oral sucker weak, usually folded, 0.08 to 0.15 wide. Acetabulum weakly developed, 0.10 to 0.13 long by 0.09 to 0.12 wide. Sucker ratio 1:0.8 to 1.1. Forebody 29 to 34% of body length. Prepharynx shorter or longer than pharynx. Pharynx 0.05 to 0.06 long by 0.05 to 0.06 wide. Esophagus 0.07 to 0.10 long. Intestinal bifurcation usually nearer acetabulum than oral sucker. Caeca terminating near end of body.

Testis slightly irregular, submedian, 0.10 to 0.25 long by 0.08 to 0.12 wide. Posttesticular space 20 to 34% of body length. Cirrus sac large, arcuate, 0.22 to 0.30 long by 0.07 to 0.10 wide, extending near or into gonadal zone; containing ovoid seminal vesicle, well-developed prostatic cells, large saccate cells opening into pars prostatica, long cirrus with thorn-shaped spines 8 to 19 microns long. Genital atrium unspined. Genital pore median or submedian, anterior to acetabulum.

Ovary 0.10 to 0.20 long by 0.07 to 0.14 wide, lobed or unlobed; if lobed, with 3 or 4 lobes; slightly dextral to overlapping testis. Vitelline follicles in compact groups, at gonadal level, intercaecal or overlapping caeca. Terminal organ partially collapsed, not over ½ as long as cirrus sac; anterior portion with spines 16 to 21 microns long, posterior portion unspined. Uterus not extending past midposttesticular level, entering terminal organ near junction of spiny and unspined portions. Eggs 11 to 17 by 9 to 10 microns.

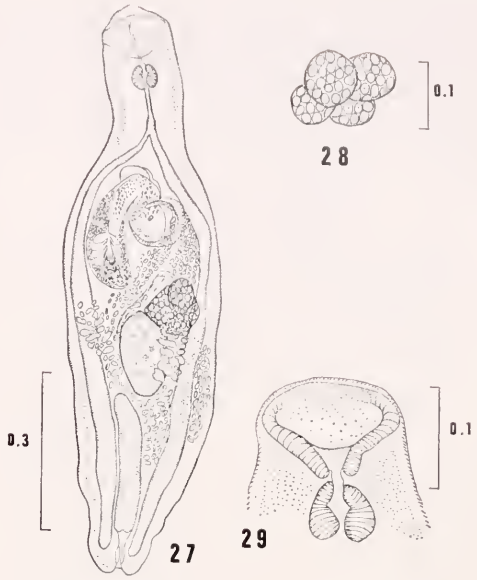

Figure 27. *Lasiotocus mugilis*, holotype, dorsal view. Figure 28. *Lasiotocus mugilis*, ovary from different specimen. Figure 29. *Lasiotocus mugilis*, anterior end.

Excretory vesicle I-shaped, epithelial, extending near or into testicular level; pore terminal.

Discussion: Several species of *Lasiotocus* have caeca extending to near the end of the body and vitellaria at the gonadal level. This species can be differentiated from *L. latus* (Manter, 1942) by body shape and arrangement of gonads; from *L. beauforti* (Hopkins, 1941) by length of excretory vesicle, number of posttesticular uterine coils, and sucker ratio; from *L. longicaecum* Manter, 1940, by body shape and character of oral sucker; from *L. chaetodipteri* Thomas, 1959, by the body shape and amount of posttesticular space; from *L. longovatus* (Hopkins, 1941) and *L. pritchardae* Nahhas and Cable, 1964, by sucker ratio and size of eggs; from *L. malasi* (Nagaty, 1948) by

the site of the vitellaria and length of esophagus and eggs; from *L. himezi* Yamaguti, 1951, *L. odhneri* (Srivastava, 1939), and *L. cacuminata* (Nicoll, 1915) by size of body and eggs and number of posttesticular uterine coils.

Lasiotocus **haemuli** sp. n.
Figure 30

Hosts: *Haemulon plumieri* (2 of 5), type host; *Haemulon sciurus* (2 of 6).
Site: Intestine and pyloric caeca.
Holotype: U. S. N. M. Helm. Coll. No. 71312, paratype: No. 71373.

Description (based on 18 specimens): Body elongate, 0.49 to 0.93 long by 0.16 to 0.22 wide, usually widest at midbody; posterior end pointed or rounded; usually a constriction immediately posterior to level of oral sucker. Cuticle completely spinose. Eyespots absent. Oral sucker terminal, funnel-shaped, 0.11 to 0.17 long by 0.10 to 0.15 wide. Acetabulum weakly developed, 0.05 to 0.06 long by 0.05 to 0.07 wide. Sucker ratio 1:0.4 to 0.6. Forebody 29 to 48% of body length. Prepharynx shorter than pharynx. Esophagus usually shorter than pharynx. Intestinal bifurcation a short distance anterior to acetabulum. Caeca terminating beyond middle of posttesticular space.

Testis slightly irregular, 0.07 to 0.13 long by 0.05 to 0.10 wide. Posttesticular space 17 to 35% of body length. Cirrus sac arcuate, 0.11 to 0.18 long by 0.03 to 0.05 wide, extending around left or dorsal of acetabulum to or near ovarian level; containing large ovoid seminal vesicle, prostatic cells, saccate cells opening into pars prostatica, cirrus with thorn-shaped spines 4 to 5 microns long. Genital atrium short, unspined. Genital pore anterior to acetabulum, sometimes ventral to intestinal bifurcation.

Ovary varying from slightly irregular to triangular, never dextral, and occasionally sinistral to median line through testis, 0.05 to 0.10 long by 0.05 to 0.09 wide. Seminal receptacle absent. Vitelline follicles in lateral groups, 8 to 10 on each side, between levels of acetabulum and ovary. Terminal organ 0.05 to 0.10 long by 0.03 to 0.05 wide, 30 to 90% length of the cirrus sac; proximal vesicle unspined; anterior portion with spines 5 microns long. Uterus may or may not extend past caecal termination, entering terminal organ at junction of spiny and unspined portions. Eggs 17 to 24 by 11 to 13 microns.

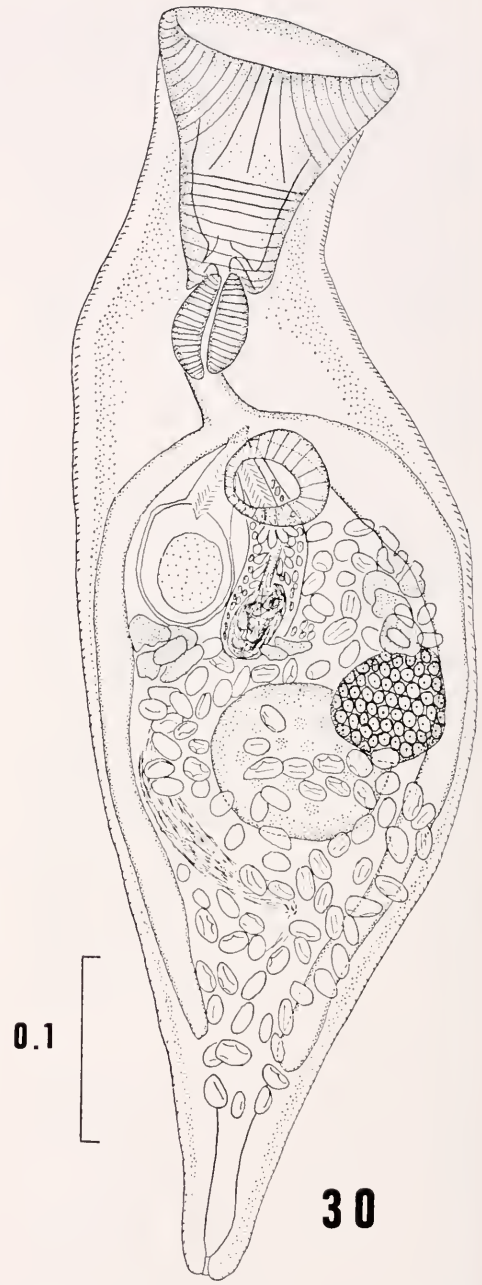

Figure 30. *Lasiotocus haemuli*, holotype, ventral view.

Excretory vesicle short, usually extending to level of caecal termination; pore terminal.

Discussion: *Lasiotocus haemuli* is found with *L. truncatus* and resembles that species but differs from it by having a larger sucker ratio, a non-dextrally located ovary, and a larger pharynx compared with the width of the neck. *Lasiotocus haemuli* differs from *L. longovatus* in the arrangement of the gonads and size and shape of eggs. *Lasiotocus beauforti* and *L. longicaecum* differ from *L. haemuli* in that they are longer; also, *L. beauforti* has a longer genital atrium and *L. longicaecum* has longer caeca and a different position of the cirrus sac. *Lasiotocus pritchardae* (Nahhas and Cable, 1964) is a larger species with a distinctly lobed, dextrally located ovary.

Lasiotocus **albulae** sp. n.
Figures 31 and 32

Host: *Albula vulpes* (6 of 7), type host.
Site: Intestine and pyloric caeca.
Holotype: U. S. N. M. Helm. Coll. No. 71313, paratype: No. 71374.

Description (based on 15 wholemounts and 3 sectioned specimens): Body elongate, 0.7 to 1.2 long by 0.17 to 0.35 wide, slightly wider at acetabular level; neck region attenuated. An immature individual 1.1 long. Spines on entire cuticle, more numerous on neck region. Eyespots or dispersed pigment granules in pharyngeal to midesophageal region. Oral sucker sometimes slightly tapered posteriorly but not funnel-shaped, 0.06 to 0.09 long by 0.08 to 0.10 wide. Acetabulum weakly developed, 0.07 to 0.12 by 0.08 to 0.12. Sucker ratio 1:1.0 to 1.3. Forebody 32 to 52% of body length. Prepharynx contracted, or elongated up to 0.07 in length. Pharynx 0.05 to 0.06 long by 0.04 to 0.05 wide; widest just postequatorial. Esophagus 2 to 5 times length of pharynx. Intestinal bifurcation anterior to acetabulum. Caeca terminating from level of posterior border of testis to near the end of the body.

Testis elongate, 0.10 to 0.17 long by 0.06 to 0.13 wide, in posterior ⅓ to ¼ of body. Posttesticular space 8 to 21% of body length. Cirrus sac slightly to strongly arcuate, 0.16 to 0.28 long; from midway between acetabulum and ovary and ovary; passing at a level dorsal to acetabulum; containing unipartite seminal vesicle, large saccate cells opening into pars prostatica, conspicuous prostatic cells, muscular cirrus with wide-based spines 4 to 5 microns long. Genital pore posterior to caecal bifurcation, median or slightly sinistral. Large, unspined genital atrium.

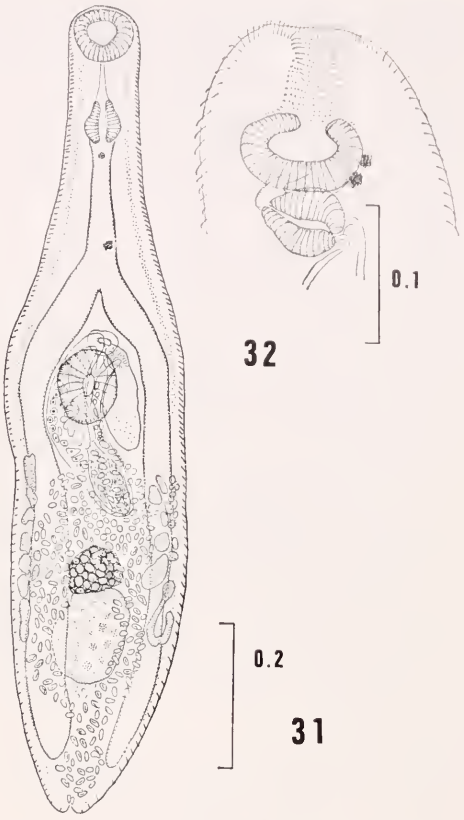

Figure 31. *Lasiotocus albulae*, holotype, ventral view. Figure 32. *Lasiotocus albulae*, withdrawn oral sucker.

Ovary subglobular to subtriangular, 0.04 to 0.09 long by 0.05 to 0.10 wide, median to slightly dextral, overlapping anterior edge of testis. Terminal organ well developed, about ¾ as long as cirrus sac; anterior portion with slender spines up to 8 microns long; posterior portion unspined. Vitellaria 8 to 10 large or numerous small follicles on each side, from level of middle or posterior end of cirrus sac to near or beyond posterior border of testis. Many sperm in proximal loops of uterus. Uterus filling body beyond middle or posterior end of cirrus sac; distal portion muscular, entering termi-

nal organ between middle of spiny portion and its junction with unspined portion. Eggs 13 to 17 by 8 to 11 microns.

Excretory vesicle short, occasionally overlapping testis posteriorly; pore terminal.

Discussion: The body is delicate and may be extended greatly. The anterior portion of the worm may be retracted within the body (Figure 32).

Lasiotocus albulae resembles *L. delicatus* Manter and Pritchard, 1961, in having a long esophagus and an oral sucker that is not funnel-shaped. It is, however, smaller than that species, has extensive vitellaria, and is most easily distinguished from *L. delicatus* by the presence of eyespot pigment.

Postmonorchis orthopristis
Hopkins, 1941

Pristisomum orthopristis (Hopkins, 1941) Yamaguti, 1958.

Hosts: *Anisotremus virginicus* (1 of 6)*; *Haemulon aurolineatum* (4 of 7)*; *Haemulon parrai* (2 of 7)*; *Haemulon plumieri* (3 of 5); *Haemulon sciurus* (3 of 6).

Site: Intestine.

Discussion: Manter and Pritchard (1961: 483-484) discussed the invalidity of the generic name *Pristisomum*.

Variability exists in some characters of my specimens. The vitellaria may be at the level of the testis in addition to being anterior to this zone. The cirrus sac may be almost ½ instead of only ⅓ as long as the body. Hopkins (1941:396-397) did not observe the uterus posterior to the testis in any of 106 specimens, but in a few of mine it fills all the available posttesticular space.

Diplomonorchis leiostomi Hopkins, 1941

Diplomonorchis micropogoni Nahhas and Cable, 1964 (new synonym).

Hosts: *Archosargus rhomboidalis* (3 of 5); *Lagodon rhomboides* (2 of 5); *Orthopristis chrysopterus* (3 of 4).

Site: Pyloric caeca and intestine.

Discussion: Considerable variation exists in this species. The testes and vitellaria may be from equatorial in position to within the posterior half of the body. The uterus may have loops at the bifurcal level on one or both sides, the caeca may or may not extend beyond the testes, the posterior portion of the terminal organ may have a few spines or none, and the seminal vesicle may be spherical, oval, or tear-shaped. In most of my specimens, the testes are located toward the posterior end of the worm, and anterior loops of the uterus occur on both sides of the body. Nahhas and Cable (1964:206-207) distinguished *Diplomonorchis micropogoni* from *D. leiostomi* by short caeca terminating near the posterior margin of the testes and by the extent of the uterus. Since my specimens show intergradation between the two species and the two are from the same or related hosts (also see Corkum, 1966:46-47; Nahhas and Powell, 1965:17; and Sogandares-Bernal and Hutton, 1959b:62), I am reducing *D. micropogoni* Nahhas and Cable, 1964, to synonymy with *D. leiostomi.*

Diplomonorchis sphaerovarium
Nahhas and Cable, 1964

Host: *Ophichthus gomesi* (1 of 1)*.

Site: Intestine.

Specimen deposited: U. S. N. M. Helm. Coll. No. 71314.

Discussion: My specimens differ somewhat from the published description. In some, the gonads are irregularly shaped and in others the ovary has three to four indistinct lobes, suggesting that the species is not as atypical as Nahhas and Cable (1964:209) suspected. The large gland cells in the forebody may extend into the hindbody, and the esophagus is not necessarily shorter than the pharynx. Some mature worms are 0.71 long, although immature worms are often larger. Dr. R. M. Cable lent a slide with 12 immature specimens which revealed spines in the posterior portion of the prepharynx, as in my material. The seminal vesicle in some of my specimens appears indistinctly bipartite. In describing *D. sphaerovarium,* Nahhas and Cable (1964:209) broadened the concept of the genus *Diplomonorchis* so that it differs from *Diplomonorcheides* Thomas, 1959, only in possessing species with a unipartite rather than bipartite seminal vesicle. Because Thomas (1959, Figures 9 and 10) figured the seminal vesicle of *Diplomonorcheides magnacetabulum* as being clearly unipartite, I propose *Diplomonorcheides* as a synonym of *Diplomonorchis*, with *Diplo-*

monorchis magnacetabulum (Thomas, 1959) as a new combination.

Hurleytrema eucinostomi
Manter, 1942

Pseudohurleytrema eucinostomi (Manter, 1942) Yamaguti, 1954.

Host: *Eucinostomus gula* (3 of 3).
Site: Rectum.
Discussion: Eight mature specimens differ slightly from the original description. The eyespots are more anteriorly located than originally described and the caeca may extend almost to the midtesticular level. The ovary is usually distinct and dextral. The testis is elongate, with the width 40 to 80% the length. The specimens are 0.52 to 1.24 long, with an immature specimen 0.50 long. Sucker ratios are 1:0.8 to 1.0, usually 1:0.98. The eggs measure 18 to 27 by 14 to 17 microns. Nahhas and Cable (1964:204) gave measurements of specimens from Jamaica, Curaçao, and Puerto Rico.

Hurleytrema shorti (Nahhas and Powell, 1965) comb. n.

Pseudohurleytrema shorti Nahhas and Powell, 1965.
Pseudohurleytrema ottoi Travassos, Freitas, and Bührnheim, 1965 (new synonym).

Host: *Selene vomer* (2 of 2).
Site: Intestine, pyloric caeca, and stomach.
Discussion: My specimens are extremely gravid. The smallest specimen is 0.46 long. Measurements of the organs are slightly less than those of the original description. The acetabulum is weakly developed and the sucker ratio is 1:1.0 to 1.5. Eggs measure 24 to 30 by 13 to 16 microns, with filaments up to at least 3.5 times the length of the eggshell. The caeca may extend posterior to the vitellaria.

I agree with Manter and Pritchard (1961: 487) that *Pseudohurleytrema* Yamaguti, 1954, is a synonym of *Hurleytrema* Srivastava, 1939, and that *Hurleytrema* be temporarily distinguished from *Hurleytrematoides* Yamaguti, 1954, by including species with a unipartite rather than a bipartite seminal vesicle.

The genus *Hurleytrematoides* accordingly includes *H. chaetodoni* (Manter, 1942), *H. coronatum* Manter and Pritchard, 1961, and *H. curacaensis* Nahhas and Cable, 1964; and the genus *Hurleytrema* includes *H. ovocaudatum* Srivastava, 1939, *H. eucinostomi* Manter, 1942, *H. longitestis* Bravo-Hollis, 1956, *H. trachinoti* Thomas, 1959, *H. malabonensis* (Velasquez, 1961) comb. n., *H. shorti* (Nahhas and Powell, 1965) comb. n., and the new species described next. *Pseudohurleytrema ottoi* Travassos, Freitas, and Bührnheim, 1965, from *Selene vomer* in Brazil and *H. shorti* are the same species. The description of *H. shorti* appeared earlier in 1965 than did that of *P. ottoi*. This synonymy is also recognized by Freitas, Travassos, and Kohn (Freitas, 1968: personal communication).

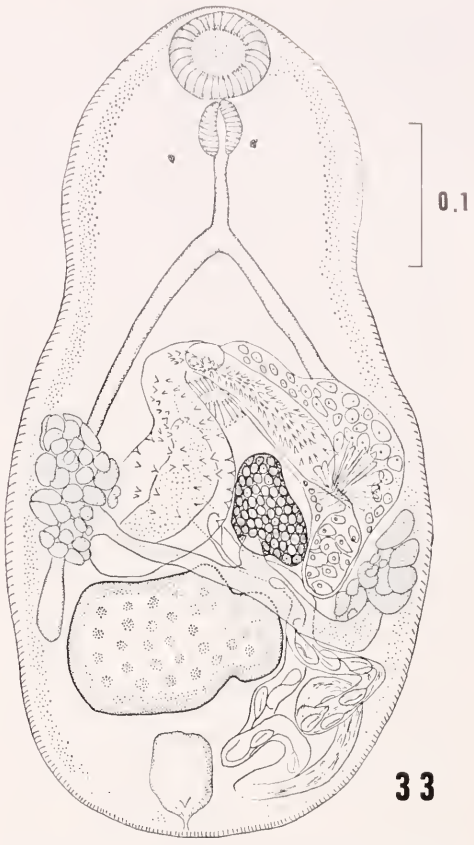

Figure 33. *Hurleytrema pyriforme*, holotype, dorsal view.

Hurleytrema **pyriforme** sp. n.
Figure 33

Host: *Trachinotus falcatus* (1 of 6), type host.
Site: Pyloric caeca.

Holotype: U. S. N. M. Helm. Coll. No. 71315, paratype: No. 71375.

Description (based on 5 apparently recently matured specimens): Body pyriform, 0.52 to 0.63 long by 0.28 to 0.33 wide; widest at gonadal level. Cuticle completely spinose. Eyespots at pharyngeal-esophageal level. Oral sucker 0.05 to 0.07 long by 0.07 to 0.08 wide. Acetabulum weakly developed, 0.04 to 0.05 by 0.05 to 0.06. Sucker ratio 1:0.8; 1:0.6 to 0.7 in 6 additional specimens without eggs. Forebody 40 to 48% of body length. Prepharynx 0.01 long. Pharynx 0.04 long by 0.03 to 0.04 wide. Esophagus 0.05 to 0.07 long. Intestinal bifurcation about midway between suckers. Caeca extending almost to or slightly past testis.

Testis single, 0.07 to 0.10 long by 0.15 to 0.18 wide, sinistral, slightly irregular, 0.08 to 0.12 from acetabulum. Cirrus sac large, arcuate, over 0.20 long, extending to testicular level; containing oval seminal vesicle, saccate cells opening into pars prostatica, numerous prostatic cells, cirrus with spines 6 to 11 microns long. Cirrus ½ or more the length of cirrus sac. Genital atrium unarmed. Genital pore immediately anterior to acetabulum, median to slightly sinistral.

Ovary small, longer than wide, swollen at connection with oviduct, dextral and slightly anterior to testis. Seminal receptacle absent; proximal folds of uterus containing sperm. Uterus extending to a level posterior to testis, entering terminal organ near junction of its spiny and unarmed portions. Terminal organ over ¾ as long as cirrus sac; distal portion tubular, heavily spined, anterior portion and sometimes almost all of proximal chamber with spines 5 to 12 microns long with sharp points and wide bases, as spines of cirrus. Vitelline follicles in 2 lateral clusters, between or overlapping acetabulum and testis; may or may not overlap caeca. Vitelline ducts large. Newly-formed eggs 14 to 21 by 11 to 12 microns with filament 2 to 4 times the length of the eggshell.

Excretory vesicle saccate, not reaching testis; collecting ducts sometimes swollen, extending, at least, to vitelline region. Excretory pore terminal to slightly ventral.

Discussion: *Hurleytrema pyriforme* resembles *H. trachinoti* Thomas, 1959, which is found in the same genus of host. It differs from *H. trachinoti* in that the oral sucker is more spherical than funnel-shaped; the oral sucker, acetabulum, and pharynx are half as large; the excretory vesicle does not extend to the testis; and the distance between the acetabulum and testis is greater. Also, the cirrus sac in *H. pyriforme* is larger and contains a unipartite seminal vesicle, the spines in the terminal organ are situated farther posteriorly, and the vitellaria are more compact.

Nahhas and Powell (1965:19) erected the genus *Parahurleytrema* with *P. trachinoti* as type species, characterized by a bipartite seminal vesicle and the uterus entering the terminal organ near the junction of the spiny anterior and unarmed posterior portions. Since the present species, with a unipartite seminal vesicle, shows such a close relationship to *H. trachinoti* and the illustration of the seminal vesicle of *H. trachinoti* by Thomas (1959:106) reveals a rather indistinct bipartite condition, I place *Parahurleytrema* as a synonym of *Hurleytrema*; *P. coronatum* (Manter and Pritchard, 1961) is therefore *Hurleytrematoides coronatum*, as originally described.

FAMILY CRYPTOGONIMIDAE Ciurea, 1933

Siphodera vinaledwardsii (Linton, 1901) Linton, 1910

Monostomum vinaledwardsii Linton, 1901.

Hosts: *Lutjanus mahogoni* (2 of 2)*; *Lutjanus synagris* (5 of 7); *Opsanus beta* (2 of 6).

Site: Intestine and pyloric caeca.

Discussion: The size of eggs in this species is not well documented. It is 17 to 29 by 9 to 12 microns in my specimens.

Metadena globosa (Linton, 1910) Manter, 1947

Stegopa globosa Linton, 1910.

Hosts: *Lutjanus griseus* (1 of 3); *Lutjanus mahogoni* (1 of 2)*; *Lutjanus synagris* (3 of 7)*; *Ocyurus chrysurus* (4 of 5).

Site: Intestine.

Discussion: Manter (1947:333-335) and Hanson (1950:84) used several characters to distinguish *Metadena globosa* from *M. adglobosa*. After studying 27 specimens of *M. globosa* and 12 specimens of *M. adglobosa*, I believe the two may be distinguished best by uterine coils extending an-

terior to the acetabulum in *M. globosa* but not in *M. adglobosa.* The eggs are smaller in my specimens of *M. globosa*: 10 to 13 by 7 to 10 compared to 16 to 23 by 8 to 11 microns, although Manter (1947:334) reported 14 to 15 by 8 to 9 microns for *M. globosa,* and Hanson (1950:84) 10 to 27 by 7 to 12 microns for eggs of *M. adglobosa.* The body is usually more elongate in *M. adglobosa.* The diameter of the oral sucker in *M. globosa* is not always more than half the body width. The percentage is 34 to 55% compared to 35 to 45% in *M. adglobosa.* The sucker ratios are 1:0.20 to 0.51 compared to 1:0.27 to 0.32 in *M. adglobosa.* The seminal vesicle may also occasionally have coils anterior to the acetabulum in *M. globosa;* and even though the pharynx is relatively larger in *M. globosa,* it is approximately the size of the acetabulum in both species. The caeca may extend to the posterior end in both species. Several specimens of *M. globosa* have small, narrow, nondescript, cuticular appendage-like structures on the lateral and posterior margins of the body which contain cytoplasm. These processes were present on the trematodes when removed from the host and are not artifacts.

Metadena adglobosa Manter, 1947

Hosts: *Lutjanus apodus* (2 of 3); *Lutjanus griseus* (2 of 3).
Site: Pyloric caeca.

Metadena sp.

Host: *Lutjanus griseus* (1 of 3).
Site: Pyloric caeca.

Discussion: Specimens from a single *Lutjanus griseus* are similar to *Metadena adglobosa,* except they have a large, heavily-spined ventrogenital pouch. I consider these to be a new species which is described by Schroeder (in press) from the same host near Lower Matecumbe Key, Florida.

Paracryptogonimus americanus Manter, 1940

Paracryptogonimus neoamericanus Siddiqi and Cable, 1960.

Host: *Ocyurus chrysurus* (4 of 5).
Site: Intestine and pyloric caeca.

Discussion: Siddiqi and Cable (1960: 280-281) distinguished *Paracryptogonimus neoamericanus* from *P. americanus* by its smaller size, 0.64 to 0.88, compared to 2.31 to 2.38, excluding a single specimen of 1.0; fewer oral spines, 46 to 51, compared to 52 to 57; terminal oral sucker; and smaller eggs, 16 to 18 by 10 to 15, compared to 20 to 25 by 9 to 10 microns. Dr. Robert Schroeder lent 19 specimens of *P. americanus* from *Lutjanus griseus* and two from *Ocyurus chrysurus,* collected near Lower Matecumbe Key, Florida, to compare with my nine from *O. chrysurus.* Mature specimens from *L. griseus* are from 0.60 to 2.32 long, have 43 to 49 oral spines, possess primarily terminal oral suckers, and have eggs 16 to 20 by 9 to 11 microns. My specimens are 0.84 to 1.17 long, have 46 to 54 oral spines, have oral suckers appearing either terminally or subterminally, and have eggs 12 to 23 by 9 to 11 microns, usually 16 to 19 by 9 to 10 microns. Dr. R. M. Cable lent three specimens of *P. neoamericanus* from *O. chrysurus* which are 0.9 to 1.1 long. There are 45 to at least 56 oral spines, and the few noncollapsed well-developed eggs are 16 to 20 by 9 to 10 microns. This overlap between characters of *P. neoamericanus* and *P. americanus* leads me to place the former as a synonym of the latter. Even though not indicated in the description of *P. neoamericanus,* the cuticle is very thick; in fact, over 0.06 in one specimen from *L. griseus.* The cuticle in Dr. Cable's and my specimens is 12 to 25 microns at the thickest portion, in the forebody. The sucker ratios in the individuals from *L. griseus* are 1:0.5 to 0.8 and encompass the ratios of specimens from *O. chrysurus.*

Pearse (1949:36) has previously reported *P. americanus* in *Opsanus tau* from Beaufort, North Carolina.

FAMILY ACANTHOCOLPIDAE Lühe, 1909

Stephanostomum casum (Linton, 1910) McFarlane, 1934

Stephanochasmus casus Linton, 1910.
Lechradena edentula Linton, 1910.

Hosts: *Lutjanus griseus* (2 of 3); *Lutjanus synagris* (2 of 7); *Ocyurus chrysurus* (1 of 5).
Site: Rectum.

Discussion: My specimens agree with the typical example of *Stephanostomum casum* with the exception of the sucker ratio. That

is, they have 36 oral spines; eggs are 61 to 78 microns long; and metraterm and cirrus are both long and spined, with the metraterm a little shorter than the cirrus sac. The sucker ratio is 1:1.3 to 1:2.2, rather than 1:2.4 to 2.7 (Manter, 1967:personal communication), depending on the amount of expansion of the oral sucker. Manter (1947:304-305) questioned the identifications of *S. casum* from the Pacific Ocean.

Stephanostomum tenue (Linton, 1898) Martin, 1938

Distomum tenue Linton, 1898.
Distomum tenue tenuissime Linton, 1898.

Hosts: *Lutjanus apodus* (2 of 3)*; *Lutjanus mahogoni* (1 of 2)*; *Trachinotus falcatus* (2 of 6)*.
Site: Near or in rectum.

Discussion: Manter and Van Cleave (1951:328) noted that Linton (1940) might have included more than one species in his description of *Stephanostomum tenue*. The specimens I designate as *S. tenue* have a sucker ratio of 1:1.5, which is apparently typical for the species. The ratio in the specimen from *Lutjanus mahogoni* is 1:1.2, but the oral sucker is expanded. The eggs, however, are not longer than about 72 microns, whereas Linton (1940:57; 1889:536) reported 0.084 by 0.04 and 0.088 by 0.044 for eggs from specimens of *Roccus saxatilus* (= *R. lineatus*), the type host. The vitellaria in the two specimens from *L. apodus* extend to the acetabular level as in Figure 7, Plate LII (Linton, 1898) and vitellaria in the two specimens from *Trachinotus falcatus* and one from *L. mahogoni* do not extend to the acetabulum, as Linton noted later (1940:57) for another worm from *R. saxatilus*. Three specimens have 42 oral spines and a fourth 40 or 42.

Anderson (1965:71) reported *S. tenue* from the kidney of *Pomatomus saltatrix* from Sandy Hook, New Jersey, to Marathon, Florida but did not state whether it was a metacercarial or adult stage.

Stephanostomum sentum (Linton, 1910) Manter, 1947

Stephanochasmus sentus Linton, 1910.
Stephanostomum mediovitellarum Pérez Vigueras, 1955.
Stephanostomum lopezneyrai Pérez Vigueras, 1955.

Hosts: *Calamus bajonado* (1 of 1); *Haemulon carbonarium* (1 of 1)*; *Ogcocephalus cubifrons* (1 of 2)*.
Site: Rectum.

Discussion: Three specimens agree with the diagnosis of *Stephanostomum sentum* by Manter (1947:306-307), but they differ from that given by Sogandares-Bernal (1959:89) in having sucker ratios of 1:1.6, 1:1.7, and 1:1.8, rather than 1:1.0 to 1.3. The specimen from *Ogcocephalus cubifrons* is 2.4 long with eggs 74 to 78 by 39 to 41 microns, which is still larger than *S. minutum* (Looss, 1901) at 1.2 to 1.9 with eggs 47 by 36 microns. Vitellaria are poorly developed anteriorly. In the specimen from *Calamus bajonado,* the anterior testis is not formed, and the posterior one is elongated. The excretory vesicle of this species ends immediately anterior to the posterior testis. Unlike Caballero (1952), Sogandares-Bernal (1959:89) did not consider *S. sentum* a synonym of *S. minutum* because he found immature specimens of *S. sentum* larger than mature *S. minutum* occurring in the same host.

Stephanostomum ditrematis (Yamaguti, 1939) Manter, 1947

Echinostephanus ditrematis Yamaguti, 1939.
Stephanostomum longisomum Manter, 1940.
Stephanostomum filiforme Linton, 1940.
Stephanostomum manteri Pérez Vigueras, 1955.
Stephanostomum cubanum Pérez Vigueras, 1955.

Hosts: *Caranx crysos* (1 of 2); *Caranx hippos* (2 of 3).
Site: Rectum.

Discussion: The number of oral spines varies in my specimens as in those of Manter (1947:308-309). One individual clearly shows the unspined metraterm joining the cirrus sac near the base of the acetabulum. The genital atrium is unspined. Sogandares-Bernal (1959:88-89) discussed possible synonyms of *S. ditrematis*.

Stephanostomum megacephalum Manter, 1940

Host: *Caranx hippos* (2 of 3).
Site: Rectum.

Figure 34. *Stephanostomum* sp., dorsal view, vitelline follicles dorsal and ventral to gonads omitted.

Stephanostomum sp.
Figure 34

Host: *Opsanus beta* (1 of 6).
Site: Intestine.
Specimen deposited: U. S. N. M. Helm. Coll. No. 71317.

Discussion: Linton (1901:468-469) reported *Stephanostomum tenue* from *Opsanus tau* and referred to the original description (Linton, 1898:535-536). His identification probably is incorrect because he considered more than one species as *S. tenue*. The present specimen may well be a new species. It has the following characteristics: Body 1.0 long. Oral sucker 0.13 wide. Acetabulum 0.18 wide. Sucker ratio 1:1.33. Forebody 27% of body length. Apparently 38 oral spines. Prominent eyespots at level of anterior of pharynx. Esophagus about as long as pharynx. Uroproct present. Ovary 0.11 from acetabulum, with cirrus sac extending ⅔ that distance. Prostatic vesicle short. Posttesticular space 12% of body length. Gonads nearly contiguous. Vitellaria extending from midacetabular level to posterior end of body; with follicles not shown in Figure 34 dorsal and ventral to gonads; meeting dorsally between testes, but not between ovary and anterior testis as in *S. dentatum* from flounders (Manter, 1947: 308). Longest collapsed eggs 68 by 31 microns.

Manteria brachydera (Manter, 1940) Caballero, 1950

Dihemistephanus brachyderus Manter, 1940.
Stephanostomum sp. Linton, 1940.
Manteria costalimai Freitas and Kohn, 1964 (new synonym).

Host: *Oligoplites saurus* (2 of 2).
Site: Pyloric caeca.

Discussion: The present material differs from *Manteria brachydera* as described by Manter (1940a:399-400) in the respects given by Siddiqi and Cable (1960:289). The pharynx is 0.05 to 0.07 wide instead of 0.08 to 0.09. Oral spines are smaller and number 38 to 45 rather than 50 to 60, and the vitelline follicles extend farther anteriorly, relative to the seminal vesicle. Bravo-Hollis (1954:234-238) described additional material from the Pacific coast of Mexico which compared well with Manter's material from Ecuador (Manter, 1940a; Caballero, 1950). My specimens are more like the one illustrated by Siddiqi and Cable (1960, Figures 58 to 61) which reveals 32 oral spines and greater extent of vitellaria.

Freitas and Kohn (1964) erected *M. costalimai* for specimens with a wide pharynx and variation in the extent of vitellaria anteriorly. They distinguished it from *M. brachydera* by having fewer oral spines, a slightly larger acetabulum, a smaller posttesticular region, and a longer genital

atrium. Since my specimens show all but the number of oral spines to be integrated characteristics, I agree with Sogandares-Bernal and Hutton (1959a:268-269), who discussed the low number of oral spines in their material from the west coast of Florida and did not feel justified in erecting a new species on that basis. *Manteria costalimai* is therefore considered a synonym of *M. brachydera* with not more than subspecific status.

My specimens do not show the dorsal interruption of the oral spines found in some of Manter's material. Also, the tubular prostatic vesicle is very sinuous, a character not suggested in the illustrations by Siddiqi and Cable, Sogandares-Bernal and Hutton, and Freitas and Kohn. Partially-collapsed eggs measure 63 to 69 by 37 to 41 microns.

FAMILY HEMIURIDAE Lühe, 1901

Aponurus elongatus Siddiqi and Cable, 1960

Host: *Chaetodipterus faber* (1 of 2).
Site: Stomach.

Discussion: Six specimens 0.99 to 1.38 long have forebody 21 to 25% of body length, postovarian space 30 to 35% of body length, oral sucker 0.12 to 0.14 wide, acetabulum 0.26 to 0.28 wide, sucker ratio 1:1.9 to 2.3, and eggs 25 to 32 by 12 to 16 microns. Nahhas and Short (1965:45-46) distinguished this species from *Aponurus laguncula* Looss, 1907, by the larger sucker ratio (1:2.5 compared to 1:1.7 to 2.1), more elongate body, more anterior ventral sucker, greater postovarian space, and longer-than-wide vitellaria. The measurements of eggs in my specimens lie between those given by Siddiqi and Cable and those of Nahhas and Short. The hindbodies are slightly contracted, giving a shorter postovarian space, and the sucker ratio is less than 1:2.5; it is 1:2.7 from the diameters of suckers illustrated in Figure 125 of Siddiqi and Cable (1960). The vitellaria, anterior acetabulum, and postovarian space, however, are still useful in separating *A. elongatus* from *A. laguncula*. This species shows a marked similarity to *A. callionymi* Yamaguti, 1938, *A. rhinoplagusiae* Yamaguti, 1934, and *A. acroporatis* Yamaguti, 1938, all species from Japanese waters. *A. elongatus* differs from them in having slightly smaller eggs and convoluted caeca in unextended specimens. Variation in the size and shape of the seminal receptacle and vitellaria in my specimens suggests caution in appraising these characters.

Parahemiurus merus (Linton, 1910) Woolcock, 1935

Hemiurus merus Linton, 1910.
Parahemiurus parahemiurus Vaz and Pereira, 1930.
Parahemiurus platichthyi Lloyd, 1938.
Parahemiurus atherinae Yamaguti, 1936.
Parahemiurus harengulae Yamaguti, 1938.
Parahemiurus noblei King, 1962.

Hosts: *Caranx crysos* (2 of 2); *Caranx hippos* (1 of 3); *Lagodon rhomboides* (2 of 5); *Sardinella anchovia* (3 of 3).
Site: Stomach.

Discussion: Travassos *et al.* (1967:31-33) gave an extensive synonymy for *Parahemiurus merus*.

Progenetic metacercariae of *P. merus* occur in the coelom of *Sagitta hispida* from Biscayne Bay. I found a 3.2 per cent incidence of infection in 250 specimens of *S. hispida* collected by Mr. Gary Hendrix on 30 November 1967. Two of three infected chaetognaths maintained in separate beakers for 29 days had metacercariae with young eggs in the uterus. The body of the longest metacercaria of *P. merus* is 1.23.

Parahemiurus anchoviae Pereira and Vaz, 1930 Figure 35

Host: *Anchoa lyolepis* (2 of 2)*.
Site: Stomach.
Specimen deposited: U. S. N. M. Helm. Coll. No. 71318.

Description (based on 4 specimens): Body 0.51 to 0.63 long excluding ecsoma; 0.15 to 0.18 in maximum width, at vitelline level; ecsoma short, 0.06 to 0.12 long. Cuticular plications along entire body length. Oral sucker subterminal, 0.03 wide with small papillae about ventral mouth. Ventral sucker 0.07 wide. Sucker ratio 1:2.1 to 2.4. Forebody 16 to 17% of body length. Prepharynx absent. Pharynx spherical to slightly elongate, about 0.025 in diameter. Esophagus short. Caeca terminating near or in ecsoma.

Testes near the middle of the body, tandem to diagonal, in contact or slightly separate. Genital pore ventral, at midlevel of

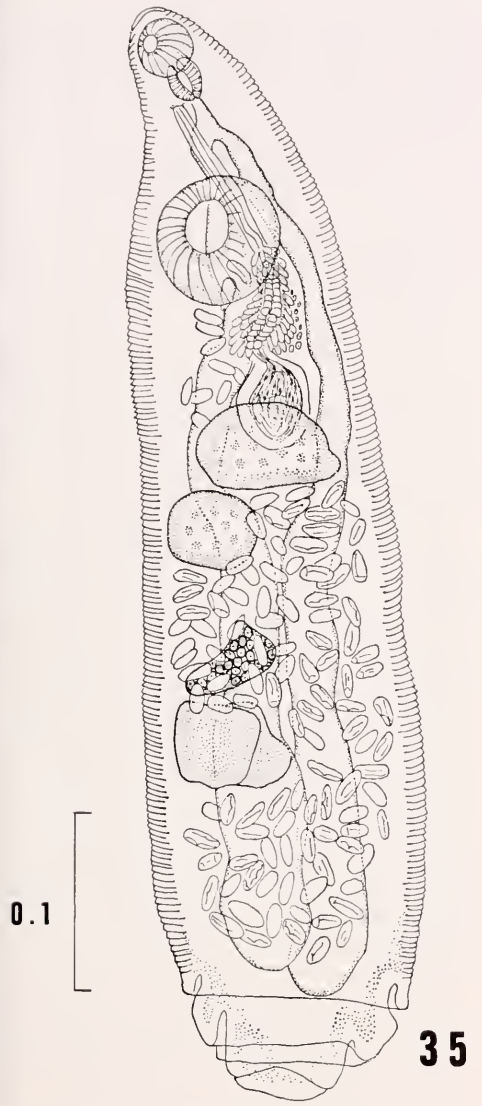

Figure 35. *Parahemiurus anchoviae,* ventral view.

oral sucker, either sinistral or dextral. Seminal vesicle muscular, 0.06 to 0.09 long by 0.04 wide, ending posteriorly in zone of anterior testis. Prostatic vesicle sometimes sinuous, as long as or longer than seminal vesicle, extending anteriorly to near mid-acetabular level, surrounded by numerous prostatic cells. Sinus sac a slender, elongated muscular tube.

Ovary spherical or slightly irregular, separated from testes by more or less than length of a testis. Vitellaria 2 large, compact, slightly irregular masses, immediately postovarian. Postvitelline region 13 to 27% of body length. Uterus extending to or into ecsoma. Eggs 19 to 25 by 9 to 11 microns.

Discussion: The present specimens differ in many respects from the original description (Pereira and Vaz, 1930b:705-706), which lacks an illustration. Their specimens are from the intestine instead of the stomach, are 1.8 rather than 0.6 long, and apparently have a greater relative length of the "pars prostatica." Also, those authors reported the cuticular plications as being more easily distinguished on the posterior ⅔ of the body, the genital pore median, the seminal vesicle not extending to the testes, the posterior extent of the uterus at the beginning of the posterior ⅓ of the body, and newly-formed eggs 28 by 8 microns. They could not determine the termination of the caeca.

Because my specimens are from a related host, host specificity in this group is low, and considerable morphological variation exists, I am not inclined to ascribe specific magnitude to the differences between the present specimens and the original description of *P. anchoviae.* This species was described from *Anchovia olida,* probably a synonym of *Lycengraulis olidus* (Günther, 1874), also from Brazil and in the same family as *Anchoa lyolepis.*

Parahemiurus anchoviae differs from other species with cuticular plications along the entire body. *P. clupeae* Yamaguti, 1953, is much larger and has a long ecsoma; *P. equadori* Manter, 1940, has the oral sucker larger than the acetabulum and an elongated pharynx; and *P. australis* Woolcock, 1935, has a more elongated seminal vesicle. The plications also extend near or to the end of the body in *P. lovelliae* Crowcroft, 1947, in which the seminal vesicle reaches the ovary.

Ectenurus americanus (Manter, 1947) Manter and Pritchard, 1960

Parectenurus americanus Manter, 1947.
Magnacetabulum americanum (Manter, 1947) Yamaguti, 1954.

Host: *Synodus foetens* (3 of 7).
Site: Stomach.

Ectenurus virgulus Linton, 1910

Hosts: *Caranx crysos* (1 of 2)*; *Caranx hippos* (1 of 3).
Site: Stomach.

Sterrhurus musculus Looss, 1907

Sterrhurus laeve (Linton, 1898) of Manter, 1931 (in part).
Sterrhurus floridensis Manter, 1934 (in part).
Brachyphallus musculus (Looss, 1907) Skrjabin and Guschanskaja, 1955.

Hosts: *Achiris lineatus* (1 of 1); *Anisotrema virginicus* (1 of 6)*; *Caranx hippos* (1 of 3)*; *Diplectrum formosum* (3 of 4); *Epinephelus striatus* (1 of 2)*; *Eucinostomus gula* (1 of 3)*; *Haemulon aurolineatum* (1 of 7)*; *Haemulon parrai* (1 of 7)*; *Lutjanus apodus* (1 of 3); *Lutjanus griseus* (2 of 3); *Ogcocephalus cubifrons* (2 of 2); *Orthopristis chrysopterus* (2 of 4); *Paralichthys albigutta* (1 of 1); *Scorpaena plumieri* (1 of 4); *Synodus foetens* (5 of 7).
Site: Stomach; also intestine of *O. cubifrons*.

Lecithochirium parvum Manter, 1947

Sterrhurus floridanus Manter, 1934 (in part).
Brachyphallus parvus (Manter, 1947) Skrjabin and Guschanskaja, 1955.

Hosts: *Archosargus rhomboidalis* (2 of 5)*; *Bathygobius soporator* (3 of 9)*; *Caranx crysos* (1 of 2)*; *Elops saurus* (2 of 3)*; *Eucinostomus gula* (1 of 3)*; *Haemulon flavolineatum* (1 of 2)*; *Lagodon rhomboides* (2 of 5)*; *Lutjanus synagris* (2 of 7)*; *Mycteroperca bonaci* (2 of 3)*; *Mycteroperca microlepis* (1 of 2)*; *Scorpaena grandicornis* (1 of 2)*; *Synodus foetens* (2 of 7).
Site: Stomach.

Discussion: Characteristics vary among specimens. The ecsoma may be extended, with the caeca terminating inside it, the testes may be separated, and the seminal vesicle is not always tripartite. Some specimens have slightly larger eggs and a slightly larger or smaller sucker ratio than described. I usually identify this species by the combination of small size, preacetabular pit, weakly-developed sinus sac, and low number of postovarian coils of the uterus. *Lecithochirium parvum* and *Sterrhurus musculus* should not be placed in the genus *Brachyphallus* Odhner, 1905, because both lack cuticular plications, a diagnostic character of *Brachyphallus*.

Lecithochirium microstomum Chandler, 1935

Sterrhurus monticelli (Linton, 1898) of Manter, 1931 (in part).
Lecithochirium sinaloense Bravo-Hollis, 1956.

Hosts: *Centropomus undecimalis* (2 of 4)*; *Epinephelus striatus* (1 of 2)*; *Lutjanus synagris* (1 of 7)*; *Mycteroperca bonaci* (2 of 3)*; *Oligoplites saurus* (2 of 2)*; *Pomatomus saltatrix* (1 of 1)*; *Synodus foetens* (2 of 7).
Site: Stomach.

Discussion: Several workers (Sogandares-Bernal and Hutton, 1959a:269; Manter and Pritchard, 1960a:94-95, 1960b:175-176; Reid, Coil, and Kuntz, 1965:203) have recently discussed variations and increased ranges of measurements in this species.

Manter (1931:406) reported *Sterrhurus monticelli* from *Pomatomus saltatrix* at Beaufort, North Carolina. In 1947 (:342) he changed the identification to a species of *Lecithochirium*, probably *L. branchialis*. He recently re-examined a specimen and found it to be *L. microstomum* (personal communication, 1968). Examination of specimens of *L. branchialis* (Stunkard and Nigrelli, 1934) may show it to be the same as *L. microstomum*.

Lecithochirium synodi Manter, 1931

Hosts: *Opsanus beta* (2 of 6)*; *Synodus foetens* (3 of 7).
Site: Stomach.

Lecithochirium sp.

Host: *Selene vomer* (1 of 2).
Site: Stomach.

Discussion: Two specimens appear to be *Lecithochirium texanus* (Chandler, 1941) Manter, 1947, although they are 1.9 to 2.1 rather than 3.25 to 3.60 in length. The sucker ratio of both is 1:3.0.

Leurodera decora Linton, 1910

Host: *Haemulon aurolineatum* (1 of 7)*.
Site: Stomach.

Brachadena pyriformis Linton, 1910

Distomum bothryophoron (Olsson, 1868) of Linton, 1901 and 1905 (in part).
Lecithaster anisotremi MacCallum, 1921.
Lecithaster gibbosus (Rudolphi, 1802) of Linton, 1940 (in part).
Aponurus symmetrorchis Siddiqi and Cable, 1960.

Hosts: *Anisotremus virginicus* (2 of 6); *Calamus bajonado* (1 of 1); *Haemulon carbonarium* (1 of 1)*; *Haemulon parrai* (2 of 7).
Site: Stomach.

Myosaccium opisthonemae (Siddiqi and Cable, 1960) comb. n.

Neogenolinea opisthonemae Siddiqi and Cable, 1960.

Host: *Sardinella anchovia* (3 of 3).
Site: Stomach.

Discussion: Twelve specimens ranging from 0.44 to 0.90 long with sucker ratios of 1:1.6 to 1.8 and eggs 21 to 26 by 9 to 11 microns compare well in all respects with what Siddiqi and Cable (1960:313) called *Neogenolinea opisthonemae* except that eggs are smaller than 29 to 32 by 12 to 15 microns. Partially-collapsed eggs measure 21 to 26 by 9 to 11 microns. The cuticular plications extend to the posterior end of the body on small specimens and to about the level of the vitellaria on larger ones. I do not think at this time that enough difference exists to erect a new species.

The genus *Neogenolina* is a synonym of *Myosaccium* Montgomery, 1957. I have examined a paratype of *M. ecaude,* lent by Dr. H. W. Manter, and there is some confusion in the description of *Myosaccium*. The region that Montgomery labels (1957, Figure 28) as the ejaculatory duct is the sinus organ. This is the same organ as in *Erilepturus* Woolcock, 1935, *Dinurus* Looss, 1907, and *Ectenurus* Looss, 1907, and is discussed by Manter (in press). The muscle fibers surrounding the prostatic vesicle are spirally arranged, rather than distinctly longitudinally, and the internal vesicular cells do not reveal nuclei. The specimens from *Sardinella anchovia* do not have filaments or spines on the eggs, although a look at collapsed specimens on a fixed plane strongly suggests their presence. Specimens from *Opisthonema oglinum* lent by Dr. R. M. Cable also do not have filamented eggs. The paratype of *M. ecaude* has collapsed eggs crowded together, and I could not positively distinguish any filaments. Filaments are probably not present on the eggs of this species. These corrections in Montgomery's description remove supposed differences of *Myosaccium* from *Neogenolina*. Kohn and Bührnheim (1964), however, also report *M. ecaude* with filamented and spined eggs. Their specimens were collected from *Sardinella aurita* in Brazil and are 0.65 to 1.04 long with eggs 30 to 41 by 9 to 13 microns. *M. opisthonemae* could well be small or progenetic forms of *M. ecaude*. Study of additional specimens probably can settle this problem.

Opisthadena dimidia Linton, 1910

Opisthadena cortesi Bravo-Hollis, 1966 (new synonym).

Host: *Kyphosus sectatrix* (6 of 6).
Site: Stomach.

Discussion: Bravo-Hollis (1966:144) used six characters to separate *Opisthadena cortesi* Bravo-Hollis, 1966, from *O. dimidia*. I do not find these differences to be valid because of the intergradation discussed below, and consider the two species synonymous. My 18 mounted specimens have sucker ratios of 1:2.3 to 3.4 and diameter-of-pharynx to diameter-of-oral sucker ratios of 1:1.4 to 1.7. The genital pore is usually at a level just below the pharynx, and the sinus sac is along the anterior border of the acetabulum, but if specimens are fixed in certain positions, those features appear to be more anterior or posterior than usually observed. Also depending on fixation, the seminal receptacle may be anterior to the ovary, even with that gonad, or anywhere between. The eggs are 25 to 45 by 12 to 17 microns, some specimens having larger eggs than others.

Dictysarca virens Linton, 1910

Host: *Hippocampus erectus* (2 of 4).
Site: Swim bladder.

Discussion: My two specimens have measurements and ratios which fall between those given by Linton (1910:58-59) and Manter (1947:364-365). A difference, however, is that the ovary is not completely posterior to the vitellaria. One specimen

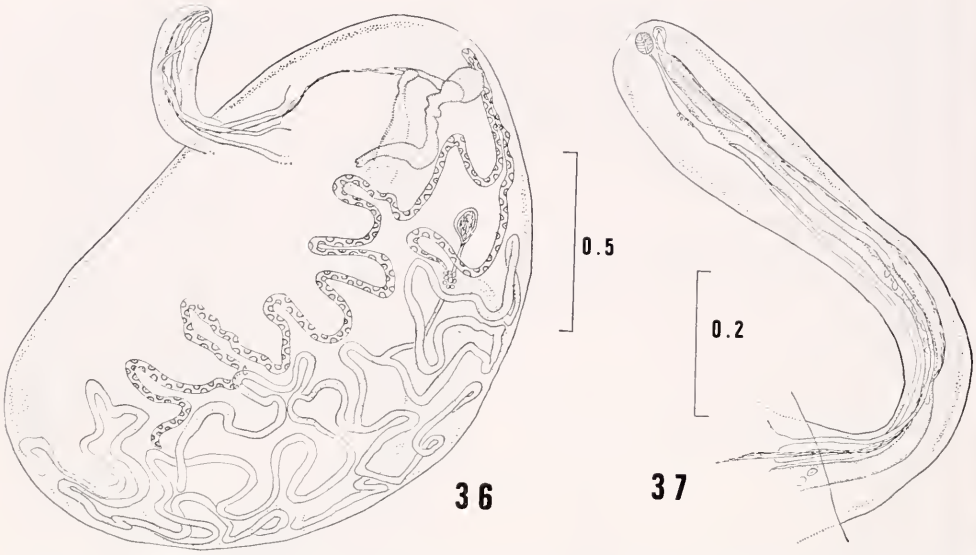

Figure 36. *Didymocystis scomberomori.* Figure 37. *Didymocystis scomberomori,* anterior end.

has one testis only. The eggs measure 24 to 35 by 12 to 19 microns.

Daigger and Lewis (1967:8) reported *Dictysarca virens* in Biscayne Bay from the same host, under its synonym *Hippocampus punctulatus.* The trematode was previously known only from swim bladders of moray eels.

Gonocercella trachinoti (MacCallum, 1913) Yamaguti, 1954

Distomum sp. Linton, 1905 (from *Trachinotus carolinus*).
Distomum trachinoti MacCallum, 1913.
Gonocercella atlantica Manter, 1940.

Host: *Albula vulpes* (2 of 7)*.
Site: Stomach and upper intestine.

Discussion: Of five specimens with developed gonads, the two largest are contracted specimens 2.4 and 2.5 long that have poorly-formed eggs, such as those reported for the type of *Gonocercella pacifica* (Manter, 1940a:437-439). MacCallum (1913:410-411) described *Distomum trachinoti* from *Trachinotus carolinus* from which Linton (1905:367) described *Distomum* sp. Both authors were confused in interpreting the vitellaria. Apparently unaware of MacCallum's paper, Manter (1940a:437-439) erected *G. atlantica* and later (1947: 358) separated *G. atlantica* from *G. pacifica* by the presence of more profuse prostatic cells, longer and more coiled seminal vesicle, and shorter eggs (27 compared with 34 microns). My specimens are like *G. atlantica,* except that eggs from the most mature specimens are 49 to 59 by 21 to 29 microns and the testes are symmetrical, as illustrated by Pearse (1949), rather than diagonal. MacCallum, however, described eggs as 0.09 long by 0.03 wide. Numerous gland cells surround the spherical excretory vesicle in my specimens. The study of fully-mature specimens will permit better understanding of the genus. Manter, Pearse, and MacCallum reported *G. trachinoti* from *Monacanthus hispidis*, *Fundulus majalis*, and *Roccus saxatilus* (=*R. lineatus*).

FAMILY SCLERODISTOMATIDAE Dollfus, 1932

Sclerodistomum sphoeroidis Manter, 1947

Hosts: *Chilomycterus schoepfi* (2 of 6); *Sphaeroides testudineus* (1 of 5)*.
Site: Stomach.

Discussion: Three specimens are 4.6 to 6.4 long and have eggs 24 to 31 by 19 to 24 microns. The genital pore is at the pharyngeal level in two specimens and ⅓ the distance from the oral sucker to the acetabulum in the other. Sogandares-Bernal and Hutton (1959b:66) discussed the prob-

able error in some records of sites for species in this genus.

FAMILY DIDYMOZOIDAE Poche, 1907

Didymocystis scomberomori (MacCallum and MacCallum, 1916) Yamaguti, 1954
Figures 36 and 37

Distomum (*Koellikeria*) sp. Linton, 1901.
Koellikeria scomberomori MacCallum and MacCallum, 1916.

Hosts: *Scomberomorus maculatus* (2 of 2); *Scomberomorus regalis* (1 of 2)*.

Site: Encysted in pairs in wall of stomach, intestine, and pyloric caeca.

Specimen deposited: U. S. N. M. Helm. Coll. No. 71319.

Description (based on 24 wholemounts and 1 sectioned cyst): Hermaphroditic, enclosed as pair in globular to subglobular cyst. Hindbody hemispherical to reniform, 0.43 to 1.32 long at median axis by 0.86 to 2.17 wide in wholemounts. Forebody attaching near anterior margin of hindbody, 0.23 to 0.92 long by 0.07 to 0.16 wide; widest at anterior level. Oral sucker replaced by a spherical glandular organ, sometimes overlapping pharynx. Pharynx muscular, 0.021 to 0.035 long by 0.017 to 0.026 wide. Esophagus longer or shorter than ½ width of forebody. Caeca usually narrow in forebody, and vesicular in hindbody.

Testes tubular, paired, near midlevel at side of hindbody; straight, arcuate, or sinuous. Genital pore subterminal or terminal, near pharynx. Vas deferens sinuous or not.

Ovary tubular, either undivided or dividing near seminal receptacle into 2 stems, usually of unequal length, each extending in opposite directions, winding sinuously along lateral and posterior margins of hindbody, without secondary branching. Seminal receptacle saccate, site variable from almost median to midway to lateral margin, near base of hindbody or well interior. Mehlis's gland lateral to receptacle. Vitellaria tubular, slender, sinuous, extending along posterior or dorsolateral margins of hindbody; branching more in some specimens than in others; number of free ends variable; occasionally vitellaria occupying a little more than ½ of posterior margin of hindbody and a branch of ovary occupying the remainder of the margin. Uterus extensive, occupying almost all available space in hindbody. Reservoir apparently present. Eggs slightly reniform, 12 to 15 by 8 to 11 microns, usually 14 by 10 microns.

Discussion: My specimens are apparently of the same species as that reported and illustrated by Linton (1901:447) as *Distomum* (*Koellikeria*) sp. from the same host. Linton gave measurements on length, width, diameter of neck, and eggs from a single specimen. MacCallum and MacCallum (1916:153), not citing Linton's report, gave almost identical measurements for *K. scomberomori* but did not provide a detailed description.

The anterior glandular organ might be the same as the "feebly muscular" oral sucker in *D. submentalis* Yamaguti, 1938. There is a thin membrane around the structure, but the membrane is not muscular.

Discussion

Three hundred and thirty-three individuals comprising 113 species of teleost fishes were examined for digenetic trematodes. Of these fishes, 214 (64.3 per cent), representing 69 species, were parasitized by adult Digenea. This does not imply that the 44 species which were not parasitized are not definitive hosts for Digenea in Biscayne Bay, because they were represented by only 83 individuals, some of which were immature and most of which were small. Immature Digenea which might have been able to attain maturity were present in some of those fishes. Of the 69 species which harbored Digenea, only 36 of the 250 individuals examined did not have adult Digenea. Again, most of these were immature fishes or small species such as *Blennius cristatus* and *Bathygobius soporator*. Nineteen of the 69 species were infected by only one species of Digenea.

Most of the previously-described Digenea from my collection have been reported from waters south of the mainland of Florida. *Bucephaloides bennetti*, *Lepocreadium floridanum*, *Bianium vitellosum*, and *Genitocotyle cablei* have been reported previously from the Gulf of Mexico only. I suspect that these trematodes will be discovered in areas between Miami and where they were reported, when more collections are made. *Didymocystis scomberomori* is known only from the Atlantic in areas north of Florida.

Botulisaccus pisceus and *Pseudocreadium*

scaphosomum have been reported from hosts in the Pacific Ocean only. Not including *Bucephaloides arcuatus* from Pacific barracuda, which is a misidentification, there are 30 species of trematodes in my collection which are also found in hosts from the American Pacific coast. Manter, who first compared the Atlantic and Pacific faunas, listed (1940b and 1947:379) 24 common species. However, with the present knowledge, all but four species of trematodes from Biscayne Bay which are also found in the American Pacific are common to the Tortugas. Of the four, two are from hosts Dr. Manter did not examine.

Only 22 species in my study, including *Vitellibaculum spinosum* and *Lecithochirium microstomum*, have been reported from waters adjacent to the American mainland north of Biscayne Bay. This does not include species described from tropical fishes in the New York Aquarium. Fourteen additional species, however, have been reported from Bermuda. Another 18 species were reported from the Bahama Islands which were not reported from Bermuda. Sogandares-Bernal (1959:108-110) commented on the difference between Bahamian and Bermudian trematode faunas, noting that, from known collections, the Biminian fauna was more similar to the faunas of Tortugas and the American Pacific than to the Bermudian fauna.

The trematode fauna reported from Biscayne Bay seems to be more closely affiliated with the tropical faunas than with the more temperate faunas. Even though some of these trematodes are specific to tropical fishes, several others are from fishes which are present, or whose related species are present, in more northern waters. Undoubtedly, more trematode species will be reported from these and other hosts in the northern waters when parasitologists study additional collections.

The significant findings of this study are the numerous undescribed species, intermediate forms, and new host records from Biscayne Bay. I do not believe that these species or populations are restricted to this area but rather that they indicate how little is known about the Digenea from the Atlantic and Caribbean, areas that are considered to be some of the best studied in the world.

Alphabetical List of Host-Species with the Parasites Found in Each

The first number following the name of the family indicates the number of individuals examined, and the numbers in parentheses indicate the length or range of lengths of the hosts expressed as fork lengths in centimeters.

Abudefduf saxatilis (Linnaeus), sergeant major (Pomacentridae)—2 (9)
none

Acanthurus chirurgus (Bloch), doctorfish (Acanthuridae)—1 (11)
none

Achirus lineatus (Linnaeus), lined sole (Soleidae)—1 (10)
Sterrhurus musculus

Acyrtops beryllinus (Hildebrand & Ginsburg), emerald clingfish (Gobiesocidae)—3 (2)
none

Albula vulpes (Linnaeus), bonefish (Albulidae)—7 (42-65)
Botulisaccus pisceus
Claribulla longula
Diphtherostomum albulae
Gonocercella trachinoti
Lasiotocus albulae

Alutera schoepfi (Walbaum), orange filefish (Balistidae)—1 (9)
none

Anchoa lyolepis (Evermann & Marsh), dusky anchovy (Engraulidae)—2 (7)
Parahemiurus anchoviae

Anisotremus virginicus (Linnaeus), porkfish (Pomadasyidae)—6 (15-20)
Apocreadium cryptum
Apopodocotyle oscitans
Brachadena pyriformis
Diplangus parvus
Diplangus paxillus
Diphtherostomum anisotremi
Genolopa ampullacea
Helicometrina execta
Lasiotocus longicaecum
Lasiotocus longovatus
Postmonorchis orthopristis
Sterrhurus musculus

Apogon maculatus (Poey), flamefish (Apogonidae)—1 (10)
none

Archosargus rhomboidalis (Linnaeus) (= *A. unimaculatus*), sea bream (Sparidae)—5 (19-28)
Apopodocotyle oscitans
Diphtherostomum americanum
Diplomonorchis leiostomi
Lecithochirium parvum
Megasolena hysterospina
Steringotrema corpulentum

Ariosoma impressa (Poey), bandtooth conger (Congridae)—1 (24)
none

Arius felis (Linnaeus) (=*Galeichthys f.*), sea catfish (Ariidae)—2 (28-39)
none

Atherinomorus stipes (Müller and Troschel), hardhead silverside (Atherinidae)—1 (6)
none

Balistes capriscus Gmelin, gray triggerfish

(Balistidae)—4 (20-31)
Apocreadium mexicanum
Neoapocreadium coili
Pseudocreadium lamelliforme
Xystretrum solidum
Bathygobius mystacium Ginsburg (?), island frillfin (Gobiidae)—1 (5)
none
Bathygobius soporator (Valenciennes), frillfin goby (Gobiidae)—9 (5-11)
Helicometrina execta
Lecithochirium parvum
Opegaster pritchardae
Blennius cristatus Linnaeus, molly miller (Blenniidae)—6 (5-11)
Helicometra execta
Blennius marmoreus Poey, seaweed blenny (Blenniidae)—6 (5-7)
none
Calamus bajonado (Bloch & Schneider), jolthead porgy (Sparidae)—1 (28)
Host from ocean side of Sands Key
Brachadena pyriformis
Pachycreadium crassigulum
Proctocces maculatus
Stephanostomum sentum
Callionymus pauciradiatus Gill, dragonet (Callionymidae)—3 (3)
none
Caranx crysos (Mitchill), blue runner (Carangidae)—2 (20-21)
Buccephalus varicus
Ectenurus virgulus
Lecithochirium parvum
Parahemiurus merus
Stephanostomum ditrematis
Tergestia pectinata
Caranx hippos (Linnaeus), crevalle jack (Carangidae)—3 (30-46)
Buccephalus varicus
Ectenurus virgulus
Parahemiurus merus
Stephanostomum ditrematis
Stephanostomum megacephalum
Sterrhurus musculus
Carapus bermudensis (Jones), pearlfish (Carapidae)—1 (14)
none
Centropomus undecimalis (Bloch), snook (Centropomidae)—4 (50-86)
Lecithochirium microstomum
Chaetodipterus faber (Broussonet), Atlantic spadefish (Ephippidae)—2 (7-22)
Aponurus elongatus
Multitestis inconstans
Vitellibaculum spinosum
Chilomycterus schoepfi (Walbaum), striped burrfish (Diodontidae)—6 (12-17)
Diploproctodaeum vitellosum
Sclerodistomum sphoeroidis
Chriodorus atherinoides Goode & Bean, hardhead halfbeak (Exocoetidae)—1 (17)
none
Citharichthys spilopterus Günther, bay whiff (Bothidae)—3 (9-17)
none
Coryphopterus glaucofraenum Gill, bridled goby (Gobiidae)—4 (6)
none
Coryphopterus thrix Böhlke & Robins, threadfin goby (Gobiidae)—1 (5)
none
Corythoichthys albirostris Heckel, whitenose pipefish (Syngnathidae)—2 (10)
none
Dactyloscopus tridigitatus Gill, sand stargazer (Dactyloscopidae)—2 (4)
none
Diplectrum formosum (Linnaeus), sand perch (Serranidae)—4 (12-22)
Sterrhurus musculus
Diplodus holbrooki (Bean), spottail pinfish (Sparidae)—1 (19)
none
Elops saurus Linnaeus, ladyfish (Elopidae)—3 (36-45)
Lecithochirium parvum
Epinephelus adscensionis (Osbeck), rock hind (Serranidae)—1 (21)
Helicometra torta
Epinephelus striatus (Bloch), Nassau grouper (Serranidae)—2 (33-38)
Helicometra torta
Lecithochirium microstomum
Sterrhurus musculus
Equetus acuminatus (Bloch & Schneider) (= *E. pulcher*), high hat (Sciaenidae)—3 (7-9)
Manteriella crassa
Pseudopecoeloides equesi
Erotelis smaragdus (Valenciennes), emerald sleeper (Eleotridae)—1 (9)
none
Eucinostomus gula (Quoy & Gaimard), silver jenny (Gerridae)—3 (8-10)
Crassicutis marina
Hurleytrema eucinostomi
Lecithochirium parvum
Sterrhurus musculus
Eupomacentrus fuscus (Cuvier) (= *Pomacentrus f.*), dusky damselfish (Pomacentridae)—1 (7)
none
Eupomacentrus leucostictus (Müller & Troschel) (= *Pomacentrus l.*), beaugregory (Pomacentridae)—6 (5-9)
Diphtherostomum americanum
Eupomacentrus variabilis (Castelnau), cocoa damselfish (Pomacentridae)—1 (11)
none
Fistularia tabacaria Linnaeus, cornetfish (Fistulariidae)—1 (19)
none
Floridichthys carpio (Günther), goldspotted killifish (Cyprinodontidae)—8 (4-6)
none
Fundulus similis (Baird & Girard), longnose killifish (Cyprinodontidae)—4 (4-5)
none
Gobiesox strumosus Cope, skilletfish (Gobiesocidae)—1 (2)
none
Gobionellus smaragdus (Valenciennes), emerald goby (Gobiidae)—2 (4)
none
Gobionellus stigmaticus (Poey), marked goby (Gobiidae)—1 (5)
none

Gymnothorax nigromarginatus (Girard), blackedge moray (Muraenidae)—2 (35)
none
Haemulon aurolineatum Cuvier (= *Bathystoma a.*), tomtate (Pomadasyidae)—7 (12-17)
Apocreadium foliatum
Genolopa ampullacea
Lasiotocus longovatus
Leurodera decora
Postmonorchis orthopristis
Sterrhurus musculus
Haemulon carbonarium Poey, Caesar grunt (Pomadasyidae)—1 (21)
Apocreadium foliatum
Brachadena pyriformis
Diplangus parvus
Diplangus paxillus
Stephanostomum sentum
Haemulon flavolineatum (Desmarest), French grunt (Pomadasyidae)—2 (15-16)
Lasiotocus truncatus
Lecithochirium parvum
Genolopa ampullacea
Haemulon parrai (Desmarest), sailors choice (Pomadasyidae)—7 (15-24)
Apocreadium cryptum
Apocreadium foliatum
Brachadena pyriformis
Diplangus parvus
Diplangus paxillus
Genolopa ampullacea
Lasiotocus longovatus
Postmonorchis orthopristis
Sterrhurus musculus
Haemulon plumieri (Lacépède), white grunt (Pomadasyidae)—5 (12-17)
Diphtherostomum anisotremi
Diplangus parvus
Genolopa ampullacea
Lasiotocus haemuli
Lasiotocus truncatus
Postmonorchis orthopristis
Haemulon sciurus (Shaw), bluestriped grunt (Pomadasyidae)—6 (15-19)
Diphtherostomum anisotremi
Diplangus parvus
Diplangus paxillus
Genolopa ampullacea
Infundibulostomum spinatum
Lasiotocus haemuli
Lasiotocus longovatus
Lasiotocus truncatus
Postmonorchis orthopristis
Halichoeres bivittatus (Bloch), slippery dick (Labridae)—11 (14-19)
Helicometrina execta
Nicolla halichoeri
Halichoeres pictus (Poey), painted doncella (Labridae)—2 (19-20)
Helicometrina execta
Nicolla sp.
Halichoeres poeyi (Steindachner), blackear wrasse (Labridae)—1 (12)
none
Halichoeres radiatus (Linnaeus), puddingwife (Labridae)—8 (12-24)
Helicometrina execta
Nicolla halichoeri
Hippocampus erectus Perry (= *H. punctulatus*), spotted seahorse (Syngnathidae)—4 (13-14)
Dictysarca virens
Genitocotyle cablei
Hippocampus zosterae Jordan & Gilbert, dwarf seahorse (Syngnathidae)—1 (6)
none
Histrio histrio (Linnaeus), sargassumfish (Antennariidae)—1 (4)
none
Holacanthus isabelita (Jordan & Rutter), blue angelfish (Chaetodontidae)—1 (12)
Antorchis urna
Kyphosus sectatrix (Linnaeus), Bermuda chub (Kyphosidae)—6 (20-28)
Cadenatella americana
Cadenatella floridae
Deontacylix ovalis
Enenterum aureum
Opisthadena dimidia
Schikhobalotrema kyphosi
Labrisomus kalisherae (Jordan), downy blenny (Clinidae)—2 (8-9)
Helicometrina execta
Labrisomus nuchipinnis (Quoy & Gaimard), hairy blenny (Clinidae)—1 (17)
Helicometrina mirzai
Lactophrys quadricornis (Linnaeus) (= *L. tricornis*), cowfish (Ostraciidae)—3 (14-21)
Dermadena lactophrysi
Megapera sp.
Thysanopharynx elongatus
Lagodon rhomboides (Linnaeus), pinfish (Sparidae)—5 (14-20)
Diphtherostomum americanum
Diplomonorchis leiostomi
Lecithochirium parvum
Lepocreadium floridanum
Parahemiurus merus
Proctoeces lintoni
Steringotrema corpulentum
Lutjanus apodus (Walbaum), schoolmaster (Lutjanidae)—3 (14-22)
Helicometrina nimia
Metadena adglobosa
Stephanostomum tenue
Sterrhurus musculus
Lutjanus griseus (Linnaeus), gray snapper (Lutjanidae)—3 (18-25)
Hamacreadium mutabile
Metadena adglobosa
Metadena globosa
Metadena sp.
Stephanostomum casum
Sterrhurus musculus
Lutjanus mahogoni (Cuvier), mahogany snapper (Lutjanidae)—2 (18-23)
Helicometrina nimia
Metadena globosa
Siphodera vinaledwardsii
Stephanostomum tenue
Lutjanus synagris (Linnaeus), lane snapper (Lutjanidae)—7 (12-22)
Hamacreadium mutabile
Lecithochirium microstomum
Lecithochirium parvum
Metadena globosa

Siphodera vinaledwardsii
Stephanostomum casum

Malacoctenus macropus (Poey), rosy blenny (Clinidae)—1 (5)
none

Monacanthus ciliatus (Mitchill), fringed filefish (Balistidae)—1 (8)
none

Monacanthus hispidus (Linnaeus), planehead filefish (Balistidae)—6 (9-26)
Pseudocreadium scaphosomum
Xystretrum solidum

Mugil cephalus Linnaeus, striped-mullet (Mugilidae)—3 (23-36)
Hymenocotta manteri
Lasiotocus mugilis

Mugil curema Valenciennes, white mullet (Mugilidae)—1 (16)
none

Mycteroperca bonaci (Poey), black grouper (Serranidae)—3 (22-41)
Lecithochirium microstomum
Lecithochirium parvum
Postporus epinepheli
Prosorhynchus pacificus

Mycteroperca microlepis (Goode & Bean), gag (Serranidae)—2 (20-24)
Lecithochirium parvum
Neolepidapedon macrum
Prosorhynchus pacificus

Nicholsina usta (Valenciennes), emerald parrotfish (Scaridae)—3 (18)
Schikhobalotrema sparisoma

Ocyurus chrysurus (Bloch), yellowtail snapper (Lutjanidae)—5 (15-20)
Hamacreadium confusum
Helicometrina nimia
Lepocreadium trulla
Metadena globosa
Paracryptogonimus americanus
Stephanostomum casum

Ogcocephalus cubifrons (Richardson), batfish (Ogcocephalidae)—2 (25-28)
Helicometrina mirzai
Stephanostomum sentum
Sterrhurus musculus

Oligoplites saurus (Bloch & Schneider), leatherjacket (Carangidae)—2 (26-27)
Lecithochirium microstomum
Manteria brachydera

Ophichthus gomesi (Castelnau), shrimp eel (Ophichthidae)—1 (48)
Diplomonorchis sphaerovarium

Opsanus beta (Goode & Bean), gulf toadfish (Batrachoididae)—6 (15-34)
Helicometrina mirzai
Helicometrina nimia
Lecithochirium syuodi
Siphodera vinaledwardsii
Stephanostomum sp.

Orthopristis chrysopterus (Linnaeus), pigfish (Pomadasyidae)—4 (12-24)
Diplomonorchis leiostomi
Lasiotocus longovatus
Sterrhurus musculus

Paralichthys albigutta Jordan & Gilbert, gulf flounder (Bothidae)—1 (25)
Bucephaloides bennetti
Sterrhurus musculus

Pomacanthus arcuatus (Linnaeus) (= *P. aureus*), gray angelfish (Chaetodontidae)—4 (20-28)
Antorchis urna
Barisomum erubescens
Cleptodiscus reticulatus
Hexangitrema pomacanthi

Pomacanthus paru (Bloch) (= *P. arcuatus*, in part), French angelfish (Chaetodontidae)—1 (18)
Antorchis urna

Pomatomus saltatrix (Linnaeus), bluefish (Pomatomidae)—1 (46)
Lecithochirium microstomum

Prionotus scitulus Jordan & Gilbert, leopard searobin (Triglidae)—2 (13-23)
none

Pristigenys alta (Gill), short bigeye (Priacanthidae)—1 (6)
none

Sardinella anchovia Valenciennes, Spanish sardine (Clupeidae)—3 (12-13)
Lepocreadium pyriforme
Myosaccium opisthonemae
Parahemiurus merus

Scomberomorus maculatus (Mitchill), Spanish mackerel (Scombridae)—2 (30-35)
Didymocystis scomberomori
Rhipidocotyle adbaculum

Scomberomorus regalis (Bloch), cero (Scombridae)—2 (30-35)
Bucephaloides arcuatus
Didymocystis scomberomori
Rhipidocotyle adbaculum

Scorpaena grandicornis Cuvier, lionfish (Scorpaenidae)—2 (18-23)
Bucephalus scorpaenae
Helicometrina nimia
Lecithochirium parvum

Scorpaena plumieri Bloch, spotted scorpionfish (Scorpaenidae)—4 (21-27)
Bucephalus scorpaenae
Pseudopecoelus scorpaenae
Sterrhurus musculus

Selene vomer (Linnaeus), lookdown (Carangidae)—2 (19-21)
Hurleytrema shorti
Lecithochirium sp.
Tergestia sp.

Sparisoma aurofrenatum (Valenciennes), redband parrotfish (Scaridae)—1 (18)
none

Sphaeroides nephelus (Goode & Bean), southern puffer (Tetraodontidae)—1 (26)
none

Sphaeroides spengleri (Bloch), bandtail puffer (Tetraodontidae)—2 (11-15)
Bianium plicitum

Sphaeroides testudineus (Linnaeus), checkered puffer (Tetraodontidae)—5 (17-25)
Bianium plicitum
Sclerodistomum sphoeroidis
Xystretrum solidum

Sphyraena barracuda (Walbaum), great barracuda (Sphyraenidae)—1 (35)
Claribulla longula

Strongylura timucu (Walbaum), timucu (Belonidae)—3 (40-43)
Schikhobalotrema acutum

Symphurus plagiusa (Linnaeus), blackcheek tonguefish (Cynoglossidae)—1 (15)
none
Syngnathus floridae (Jordan & Gilbert), dusky pipefish (Syngnathidae)—6 (14-19)
none
Syngnathus louisianae Günther, chain pipefish (Syngnathidae)—3 (15-17)
none
Syngnathus scovelli (Evermann & Kendall), gulf pipefish (Syngnathidae)—2 (12)
none
Synodus foetens (Linnaeus), inshore lizardfish (Synodontidae)—7 (13-26)
Ectenurus americanus
Lecithochirium microstomum
Lecithochirium parvum
Lecithochirium synodi
Sterrhurus musculus
Trachinotus carolinus (Linnaeus), pompano (Carangidae)—1 (8)
none
Trachinotus falcatus (Linnaeus), permit (Carangidae)—6 (7-10)
Helicometrina exacta
Hurleytrema pyriforme
Stephanostomum tenue
Tylosurus crocodilus (Peron & Lesueur), houndfish (Belonidae)—1 (91)
Steganoderma nitens

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